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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

FEBRUARY 1916.

GENERAL PHYSICS.

143. *Harmonic Analysis and Synthesis of Periodic Curves.* **E. Lübcke.** (Phys. Zeits. 16. pp. 453–456, Dec. 15, 1915.)—An apparatus is described, mathematical theory being also given, which enables 7 sine- and 9 cosine-members of a Fourier's series to be determined, with a possible error of about 0·8 %. The method adopted in using the instrument makes use of 16 equidistant ordinates of the given periodic function, the length of a period of which may have any value. The instrument can also be used for obtaining the values of the 16 equidistant ordinates when the 7 sine- and 9 cosine-terms of the function are given. A. W.

144. *Apparatus for Evaluating Elliptic Integrals.* **A. F. Ravenshear.** (Phys. Soc.; Proc. 28. pp. 81–87; Disc., 87, Dec., 1915.)—In the apparatus here described, graphs of the three elliptic integrals can be described by mechanical means, and the value of the integral between any assigned limits found by measurement of the ordinates of the graph. The principle of the apparatus is to use a hatchet scriber, which is controlled as regards direction, but is otherwise free to move anywhere over the surface of the paper. The hatchet cuts slightly into the paper, and as it moves makes a trace, which is the required graph. Taking the third integral as an example $\Pi(a, c, \theta) = \int 1/[(1 + a\sin^2\theta)(1 - c^2\sin^2\theta)^{1/2}]\,d\theta$. The apparatus comprises (1) the scribing appliance; (2) a mechanism which evaluates $\sqrt{(1 - c^2\sin^2\theta)}$, where θ is the value of the abscissa of the middle point of the hatchet; (3) a mechanism which evaluates $(1 + a\sin^2\theta)$; (4) a multiplying linkage which determines a length equal to the product $(1 + a\sin^2\theta)\sqrt{(1 - c^2\sin^2\theta)}$; and (5) a director which is variably inclined to the axis of X so that the tangent of its inclination is negative and equal to the above-mentioned product. By a parallel linkage, a line in the hatchet plate at right angles to the hatchet is kept parallel to the director, so that the hatchet has an inclination ϕ to the axis of X such that $\tan\phi = 1/[(1 + a\sin^2\theta)\sqrt{(1 - c^2\sin^2\theta)}]$. Since the hatchet is always tangent to the graph which it describes, $dy/dx = \tan\phi$, whence $y = \int \tan\phi \, . \, d\theta$. By suitable adjustments the apparatus deals in a similar way with the first and second integrals. A. W.

145. *Graphical Solution of the Equation $A = B.C.$* **F. E. Wright.** (Washington Acad. Sci., J. 6. pp. 1–5, Jan. 4, 1916.)—The procedure adopted practically amounts to the representation of each of the functions A, B and C by a scale so chosen that the resulting curves are straight lines. The construction of the apparatus is based on the fact that an equation of the type $A = B.C$ can always be expressed in such a form that each factor has a value less than unity. The graphical solution can then be accomplished by a method based on the properties of similar triangles. The apparatus employed consists simply of a drawing-board covered with squared paper, at one corner of which a straight-edge fits in a fixed socket so that it is capable of rotation about this corner as axis. Examples are given of the use of the apparatus for solving equations of the type $\sin A = \sin B \,.\, \sin C$, $\log y = x \log a$, etc. A. W.

146. *Skating on Thin Ice.* **G. Greenhill.** (Phil. Mag. 31. pp. 1–22, Jan., 1916.)—The title is derived from the action of a skater, when he is able to go so fast over ice as to ride on the top of a wave, and to change his place so rapidly as not to allow time to break through, although the ice is not thick enough to support his dead weight at rest. The mathematical theory here given is an extension of Kelvin's investigation in the Phil. Mag. of Nov., 1871 (also "Math. and Phys. Papers," vol. iv.), of the propagation of waves and ripples in water, and the tremble of a dewdrop; resumed in H. Lamb's "Hydrodynamics," and by J. R. Wilton [Abs. 646 (1915)]. E. H. B.

147. *A Generalised Form of Hooke's Law.* **E. R. Hedrick.** (Eng. News, 74. pp. 542–543, Sept. 16, 1915.)—It has long been known that many materials fail to satisfy Hooke's law exactly, even within the range usually described as below the elastic limit. The author has apparently discovered that, generally speaking, the measured values of forces and extensions give a very much better straight line on logarithmic paper than on squared paper. This means that the force p and the extension e are better expressed by a relation of the form $p = ke^n$, where n may be given values other than unity.

The author has been working over the data contained in the Reports of the Watertown Arsenal, in which the numerical results of the actual tests of a large number of substances are given. For steel he finds that the value of n is quite close to unity, but in most instances definitely different, and in a few cases as low as 0·69. The majority of steel specimens gave n over 0·85, but many gave values less than 0·9. An excellent specimen of yellow pine under compression gave $n = 0{\cdot}95$. A specimen of cast steel gave $n = 0{\cdot}74$. Cast-iron specimens gave $n = 0{\cdot}69$. Sandstone gave $n = 0{\cdot}80$. A piece of manilla rope gave a good line for $n = 1{\cdot}94$. W. J. C.

148. *Agreement of the Various Frames of Reference in different Theories of Relativity.* (I. and II.) **E. Kretschmann.** (Ann. d. Physik, 48. 7. pp. 907–942, and 943–982, Dec. 21, 1915.)—An elaborate discussion, descriptive and mathematical, of the above aspect of the subject, unsuitable for detailed abstraction. E. H. B.

149. *Variation of Surface Tension with Temperature.* **A. Ferguson.** (Phil. Mag. 31. pp. 37–47, Jan., 1916.)—The formulæ, $T = T_0(1 - \alpha\theta)$...(i) and $T = T_0(1 - \alpha\theta \pm \beta\theta^2)$...(ii), which express the effect of temperature on surface tension, will not bear extrapolation over even a moderate range of temperature. If, in particular, they are used to estimate the critical temperature by calculating the value of θ for which the surface tension (T) vanishes, highly

discordant values of θ_c result. The author has shown (Science Progress, p. 445, Jan., 1915) that the surface tension of benzene between 0° and the critical temperature is represented with considerable accuracy by the equation, $T = T_0(1 - b\theta)^n$...(iii), so that the critical temperature is at once given by the expression, $\theta_c = 1/b$...(iv). Equation (iii) is both more suitable for calculating the critical temperature and more in accord with the experimental data than van der Waals' expression, $T_m = A\theta_c^{1/3}p_c^{2/3}(1 - m)^B$, where m is the "reduced" temperature and A and B are constants for all substances following Eötvös' law [Zeitsch. Phys. Chem. 13. p. 716, 1894]. Equation (iii) gives $dT/d\theta = -bnT_0(1 - b\theta)^{n-1}$ and hence $Td\theta/dT = -(1 - b\theta)/bn$, the relation between $Td\theta/dT$ and θ being linear. For a series of 14 unassociated liquids, including ether, benzene, chlorobenzene, carbon tetrachloride, and esters of fatty acids, the graphs connecting $Td\theta/dT$ and θ are very accurately linear. The values of b and n read off directly from these graphs show that $1/b$ gives the critical temperature with a very high degree of accuracy and that n varies only from 1·187 to 1·248, the mean being 1·210. This mean value may be used in calculations referring to any other non-associated liquid, since a small variation in n, at moderate temperatures, has little effect on the computed values of T or b. In all the cases considered above the surface tension measured is that of the liquid in contact with its own vapour, but the data available for benzene, methyl formate, and chlorobenzene indicate that formula (iii) is valid also for liquids in contact with air. T. H. P.

150. *Experimental Confirmation of Relativity.* **H. K. de Haas.** (K. Akad. Amsterdam, Proc. 18. No. 4–5, pp. 591–595, 1916.)—Discusses the interpretation of an experiment with a torsion balance at the extremities of which two balls of equal weight were hung, one being of Pt and the other of paraffin, of densities 21·5 and 0·87 gm. cm.$^{-3}$ respectively. It is concluded that the ether wind through the two balls, so different in constitution, did not cause any deviation of the intermolecular forces (from the direction required by Newton) so large as 1 micron at 100 light-centuries. This is claimed as an experimental confirmation of the principle of relativity. E. H. B.

151. *Viscosity of Liquefied Gases. I. Rotational Oscillations of a Sphere in a Viscous Liquid.* **J. E. Verschaffelt.** (K. Akad. Amsterdam, Proc. 18. Nos. 4–5. pp. 840–859, 1916. Comm. No. 148*b* from the Phys. Lab., Leiden.)—With a view to the investigation of the viscosity of liquefied gases, especially hydrogen, at low temperatures by the method of damped rotational oscillations of a sphere suspended in the liquid, the author gives the theory of the method. The mathematical treatment of the problem employed is less involved than that followed by previous investigators, and leads to formulæ much better adapted to numerical calculations. The liquid is assumed to be either externally unlimited or else limited by a stationary spherical surface concentric with the oscillating sphere. Detailed abstraction of the results is impracticable. T. H. P.

152. *Viscosity of Liquefied Gases. II. Similarity of the Oscillations of Spheres in Viscous Liquids.* **J. E. Verschaffelt.** (K. Akad. Amsterdam, Proc. 18. Nos. 4–5. pp. 860–867, 1916. Comm. No. 148*c* from the Phys. Lab., Leiden.)—In general, when two different spheres are undergoing rotational oscillation in two different liquids, it is not possible to choose such units of length, mass and time that the two systems become quantitatively identical. When, however, a definite state of motion is given, it is possible

to produce a similar motion in a different liquid, the conditions to which this similarity is subjected being investigated in the present paper. [See preceding Abs.] T. H. P.

153. *Coefficients of Viscosity of Mixtures of Helium and Hydrogen.* **A. Gille.** (Ann. d. Physik, 48. 6. pp. 799–837, Dec. 7, 1915. Dissertation, Halle.)—Using the transpiration method, the author has made improved measurements of the viscosity coefficients for dry air, helium, and hydrogen. Similar measurements have been made for various mixtures of helium and hydrogen at 0°, 15°, and 100°. With these mixtures the variation of the coefficients of viscosity with the temperature is accurately expressed over the interval 0–100° by Sutherland's formula, $\eta_\vartheta = \eta_0 \sqrt{(1+a\vartheta)}(1+aC)/(1+C/\theta)$, where C is the cohesion constant, ϑ the temperature in degrees Centigrade and θ the absolute temperature. This formula is, in general, undoubtedly applicable at high temperatures, but for lower temperatures its limit of applicability for medium mixtures lies near 0° C. In so far as its direction is concerned, the variation of the viscosity coefficients with the percentage composition of the mixtures follows the formula of Puluj, $\eta = \eta_1(p_1 + p_2 m_2/m_1)^{1/2}/[p_1 + (\eta_1/\eta_2 \cdot \sqrt{m_2/m_1})^{2/3} . p_2]^{3/2}$, where η, η_1, and η_2 denote the coefficients of viscosity of the mixture and of the pure components, the latter having the partial pressures p_1 and p_2 and the molecular weights m_1 and m_2. This formula gives only approximate results, which exhibit, however, a certain regularity; the characteristic bending of the curves is always increased by the formula. The results are in agreement with Thiesen's formula [see Abs. 615 (1903)]—

$$\eta = \eta_1 \Big/ \left(1 + \frac{a_{12}}{a_{11}} \cdot \frac{\phi_2}{\phi_1}\right) + \eta_2 \Big/ \left(1 + \frac{a_{21}}{a_{22}} \cdot \frac{\phi_1}{\phi_2}\right),$$

in which ϕ_1 and ϕ_2 indicate the percentage by volume of the components; consequently, if the constants a_{12}/a_{11} and a_{21}/a_{22} are determined from the known viscosity coefficients of certain mixtures, the value of η for any other mixture may be calculated with considerable accuracy. T. H. P.

154. *Magneton Theory of the Structure of the Atom.* **A. L. Parson.** (Smithsonian Misc. Collections, 65. 11. pp. 1–80, Nov. 29, 1915.)—The assumptions made by the author in the development of this theory are briefly as follows: (1) The atom is made up of a positive part and of magnetons, which are ring-shaped negative charges (hitherto called electrons and supposed to be spherical or concentrated at a point) rotating with a peripheral velocity of the order of that of light, their radii being comparable with but less than the radius of the atom; their rotation is independent of any attracting positive charge. (2) The positive part of the atom is a sphere of uniform positive electrification, with the properties of an elastic solid and with a volume normally proportional to the number of magnetons it contains. It is surrounded by an atmosphere or envelope of very low charge density which is also elastic. (3) The formation of a group of eight (of low magnetic energy), which is practically proved for a system of eight magnetons, is assumed to take place also in atoms containing more than eight. (4) To explain the occurrence of long periods in the periodic scheme and also the properties of the elements in these periods, it is necessary to assume in certain cases a hindrance to the formation of a group of eight when it is normally due. These assumptions have furnished the following factors in the behaviour of magnetons, atoms, and molecules. (*a*) The simple magnetic attraction between two magnetons. (*b*) The tendency to form the group of eight. (*c*) The residual magnetic forces exerted by all combinations of magnetons: their attracting and inducing actions. (*d*) The electric polarisation set up by the extraction of a magneton from one atom by another atom: its attracting and inducing actions. (*e*) The effect on the nature of a linkage of the electrostatic retaining power of an atom for magnetons. (*f*) The pressure and volume changes possible in the positive sphere, especially in the envelope, of the atom.

Other questions discussed include: the radius and moment of the magneton, the possibility of detecting the magneton directly, the magnetic properties of matter, of elements and of compounds, the dependence of magnetism on temperature and physical state, and Weiss's magneton and quantitative relations. Various experiments suggested by this theory are being made. T. H. P.

155. *Structure of Silver Crystals.* **L. Vegard.** (Phil. Mag. 31. pp. 83–87, Jan., 1916.)—A study of the inner structure of silver crystals, as found native. These natural crystals belong to the cubic system, and five specimens with well-developed regular crystal faces have been employed in the experiments. Bragg's method of analysis [see Abs. 1330 (1913)] has been used in the determination of reflection angles of a homogeneous beam of X-rays from a rhodium antikathode. The author arrives at the conclusion that the atoms in the silver crystals are arranged in the simple face-centred lattice. The arrangement is the same as that previously found by W. L. Bragg for copper crystals [Abs. 1903 (1914)]. A. B. W.

156. *Sub-electrons: Brownian Movement in Gases.* **A. Targonski.** (Archives des Sciences, 40. pp. 340–342, Oct., 1915. Paper read before the Soc. suisse de Physique. Comptes Rendus, 161. pp. 778–781, Dec. 30, 1915.)—Schidlof and Karpowicz pointed out that very small particles of mercury, observed in the interior of a condenser undergo constant diminution. The author finds that the diminution of mass per unit surface and per unit time is almost constant for any single particle, but varies in different particles. Some of the latter show little change, but others lose as much as 15 % of their mass in a minute. The rate of loss increases with the purity of the mercury and for distilled mercury is twice as great as for the amalgamated metal; further, particles charged positively are less stable than those carrying negative charges, this being explainable to some extent by the fact that the mercury is the more inclined to become positively charged as it becomes purer. Since any impurity modifies more especially the surface of the particles, and the capillary properties of liquids depend on the sign of their charge, it would appear that this phenomenon is determined by the surface properties. The mechanism of the phenomenon probably consists, not in evaporation, but in gradual disaggregation of the particles under the action of molecular bombardment, and there is reason to believe that similar behaviour is shown by all liquid particles, the intensity of the effect varying with the nature—probably with the viscosity—of the liquid.

Pulverisation of mercury in the voltaic arc, according to Ehrenhaft's method, yields particles with properties entirely different from those of mechanically pulverised spherules. The masses and densities are in this case quite stable and the elementary charges vary from one particle to another, are inferior to Millikan's number (sub-electrons), and depend on the radius. Calculation by means of the Stokes-Cunningham formula gives results disagreeing with those made on the basis of Brownian movement; contrary to what would theoretically be expected, the mobility of the particles, *i.e.* the speed under the influence of unit force, diminishes with the radius. It cannot, therefore, be assumed that the two kinds of particles belong to one and the same substance, and it is concluded that the particles produced in the arc are not spherules of mercury. Direct measurement shows, indeed, that these particles, at least in part, are composed of a substance with density below 7·3; the elementary charge appears to be constant and independent of the radii of the particles.

It is probable that, in its present state, the theory of Brownian movement is applicable only when the radius of the particle is small in comparison with the mean path of the surrounding gas molecules. If this condition is satisfied, the values of the elementary charge calculated on the basis of Brownian movement coincide with those of observations made by the Ehrenhaft-Millikan method. This leads to the supposition that the theory of Brownian movement is applicable rigorously only to molecular phenomena. T. H. P.

157. *On Certain Linear Differential Equations of Astronomical Interest.* **H. F. Baker.** (Roy. Soc., Phil. Trans. 216. pp. 129–186, Jan. 5, 1916.)—The author's treatment is first set forth and is then applied to the Matthew-Hill equation. In the second part it is applied to a particular case discussed by Poincaré. L. H. W.

158. *Bohr's Model Atom and Maxwell's Equations.* **C. W. Oseen.** (Phys. Zeits. 16. pp. 395–405, Nov. 1, 1915.)—Mathematical.

159. *On the Solution of Certain Problems of Two-dimensional Physics.* **J. R. Wilton.** (Phil. Mag. 30. pp. 761–779, Dec., 1915.)—Shows how the solution may be obtained in certain problems in physics, examples being worked out in illustration for some problems in hydrodynamics, gravitational potential, and figures of equilibrium of rotating fluid. [*Errata* (p. 2 of cover, January number).] L. H. W.

160. *Rotation of Elastic Bodies and the Principle of Relativity.* **P. T. Daniell.** (Phil. Mag. 30. pp. 754–761, Dec., 1915.)—Mathematical.

161. *Problem of Three Bodies from Newton to the Present Day.* **R. Marcolongo.** (N. Cimento, 9. pp. 309–367, May–June, and 10. pp. 89–130, July–Aug., 1915.)

162. *Spontaneous Currents in Liquids. Confluent Jets.* **U. Cisotti.** (N. Cimento, 10. pp. 256–316, Sept.–Oct., 1915.)—Mathematical treatment.

163. *Contraction of Liquid Jets.* **U. Cisotti.** (R. Istit. Veneto, Atti, 74. 2, 1914–15. N. Cimento, 10. pp. 317–328, Sept.–Oct., 1915.)—Aims at extending the formula of Levi-Civita for the contraction coefficient of a liquid jet escaping from an aperture in the bottom of the container. L. H. W.

164. *Skin Friction of the Wind on the Earth's Surface.* **G. I. Taylor.** (Roy. Soc., Proc. 92. pp. 196–199, Jan. 1, 1916.)—The author has already made use of the data from some pilot balloon ascents at Salisbury Plain in developing his theory of "Eddy Viscosity" [see Abs. 586 (1915)]. From these same results he now calculates the skin friction of the wind blowing

over the earth's surface and finds that it can be expressed in the form $F = \kappa\rho Q_s^2$, where κ is a constant, ρ the density of the air, and Q_s the velocity at the surface. The value of κ comes to between 0·002 and 0·008. The evidence of different wind velocities seems to prove that the friction F does vary approximately as the square of the surface velocity. From some laboratory experiments on the skin friction of air flowing through pipes it has been found that the same formula holds, in this case with a value for κ of 0·004. It appears therefore that the same law of skin friction applies to small flat plates and pipes and to the friction of the air on the ground. Such a result would be anticipated from the law of dynamical similarity provided that the value of lV/ν were the same in both cases (l a linear dimension, V velocity, ν viscosity). As actually the ratio of this quantity in the two cases is of the order of 10^5 it seems that the scale effect on skin friction over this immense range of values of lV/ν is not large. J. S. Di.

165. *Atmospheric Pollution.* **W. P. Wynne.** (Nature, 96. pp. 442–444, Dec. 16, 1915. Abstract of paper read before the British Assoc., Manchester.)—Monthly results of the chemical examination of rain-water collected at four sites in Sheffield have been published. They do not accord with expectation and certain conclusions have been reached regarding the effectiveness of this method of measuring atmospheric pollution which are of more than local interest. The records cover the period July, 1914 to June, 1915, and the results for the four stations are shown on two diagrams, one giving the monthly measurements of insoluble matter in the collected rain-water and the other of dissolved matter. It appeared probable that the amount of dissolved matter measured in any month would depend upon the amount and duration of rainfall in that month. The monthly rainfall at one of the stations (Attercliffe) has been plotted upon the same diagram as the amount of dissolved matter, and close agreement is apparent between the two curves. A similar diagram is shown for Malvern, and the similarity of the two curves is even more marked. It is concluded that the method of measurement usually adopted does not afford a reliable indication of the real degree of atmospheric pollution, and that better results might be obtained if a feasible method could be devised for drawing air continuously through water and measuring the amount of the impurities extracted in this way. J. S. Di.

166. *Shape of the Earth.* **A. R. Hinks.** (Roy. Astron. Soc., M.N. 76. pp. 8–13, Nov., 1915.)—The paper deals with a series of questions suggested by a previous paper by Jeffreys discussing the departure of the earth's surface from the hydrostatic form [Abs. 1500 (1915)]. One of the chief points requiring explanation is what is meant by hydrostatic form, as this may not be a regular spheroid, but some figure depending upon the isostatic compensation. It is also pointed out that in using geographical data the observations of recent years in Arctic and Antarctic regions have not been taken into consideration. Further, the distribution of water and land masses does not appear to be suitable for the least-square method of analysis, and this is again complicated by the abnormal distribution with respect to the equatorial plane of the proposed spheroid. C. P. B.

167. *Viscosity and the Earth's Free Precession.* **J. Larmor.** (Roy. Astron. Soc., M.N. 76. pp. 14–15, Nov., 1915.)—In a paper by Jeffreys it is calculated that an internal viscosity in the earth sufficient to account, by the lag of the solid tides, for the secular acceleration of the moon's mean motion, would

be sufficient to stop down any free precession of the pole in a few days [Abs. 418 (1915)]. It is here questioned whether the physical hypotheses involved are of reasonable probability. C. P. B.

168. *Convection in Upper Regions of Sun's Atmosphere.* **F. Henroteau.** (Roy. Astron. Soc., M.N. 76. pp. 18–22, Nov., 1915.)—From a study of spectroheliograms taken with sufficiently high dispersion to separate the higher layers of the solar atmosphere Deslandres has shown that the filaments often group themselves on a curve encircling the pole at distances varying from 50° to 70° heliographic latitude. These polar curves of filaments are in general more developed in the hemisphere, or on the meridians, where spots and faculæ are relatively feeble, and appear to be more pronounced in years of minimum spot activity. Further, they show evidence of being in general ascending currents, while the spots and faculæ are regions of descent of the vapours concerned. The present author examines the evidence for detecting any existent convection currents which might be produced as the result of this difference of atmospheric pressures. Visual observations of faculæ provide some confirmation. Other verification is furnished by the motions of prominences recorded by Slocum from measurement of photographs taken with the Yerkes spectro-heliograph. At mean latitudes there is a tendency of movement towards the poles; in high latitudes the movement is generally towards the equator. Reproductions of drawings of spots and faculæ, made at Stonyhurst are included to illustrate the phenomena described. C. P. B.

169. *Magnetic Disturbances and Solar Rotation.* **E. W. Maunder.** (Roy. Astron. Soc., M.N. 76. pp. 63–68, Nov., 1915.)—In continuation of tables given in former papers in 1904, 1905, a catalogue is presented showing the magnetic disturbances of 20′ and over in declination, as recorded in the Greenwich Observations for the period 1904–1913. The disturbances are divided into four classes: Great, Very Active, Active, Moderate, corresponding to amplitudes of 60′, 40′, 30′ or 20′ respectively. An examination of the list shows there is a strong tendency for disturbances to occur when the same meridian has returned to the centre of the sun's disc, *i.e.* after the interval of a synodic rotation of the sun. These features are in agreement with the former discussions of the results for the periods 1882–1903 and 1848–1881.
C. P. B.

170. *Dynamics of a Stellar System.* **A. S. Eddington.** (Roy. Astron. Soc., M.N. 76. pp. 37–60, Nov., 1915.)—In a former paper the author discussed the theory of a spherical stellar system, in a steady state of motion [Abs. 630 (1914); 827 (1915)]. The present paper deals with the dynamics of a system in which the restriction of spherical symmetry is removed, being applied to oblate and other systems. Starting with the consideration of all possible degrees of complexity, it is shown that Schwarzschild's ellipsoidal law of velocities can be satisfied by only one type, that in which the axes of the velocity-ellipsoids are oriented along the normals to a system of confocal quadrics. The direction of preferential motion is more or less radial, and the average motion in this direction does not diminish as we pass to the outer parts of the system. The cross motions decrease as we pass outwards, so that the velocity-ellipsoids become more elongated. Consideration is given to systems moving solely under their own attraction, and those moving under forces other than their own attraction. C. P. B.

171. *Stellar Classification.* **J. N. Lockyer.** (Nature, 96. pp. 454–455, Dec. 23, 1915.)—In continuation of previous articles [Abs. 829, 1513 (1915)] curves are presented showing the numbers of stars in each group of distinctive spectral type, determined from different catalogues of spectra. The curve for the brighter stars is in general very similar to that for the fainter stars, and the agreement affords some confirmation of the idea that the general life-history of a star consists of a rise, followed by a fall, of temperature.

C. P. B.

172. *Radial-velocity Determinations with Objective Prism.* **M. Hamy.** (Comptes Rendus, 161. pp. 661–663, Nov. 29, 1915.)—In a former paper the author has given details for determining radial velocities from objective-prism photographs provided with terrestrial spectrum comparison [Abs. 627 (1914)]. Formulæ are now given showing the application of the necessary computations for the general case where more than one prism may be employed. C. P. B.

173. *Motions of Helium Stars.* **S. Oppenheim.** (Astron. Nachr. No. 4822. Nature, 96. p. 490, Dec. 30, 1915. Abstract.)—The radial velocities observed at the Lick Observatory, and the proper motions given in the Boss Catalogue for helium stars of type B are treated harmonically, and the results are understood to establish the reality of the view that the stars, including the sun, move in circular orbits round some centre. The corresponding apex of sun's way is given as RA = 266°; decl. = + 34° 37′. C. P. B.

174. *New Variable Star in Orion.* **J. Voûte.** (Astron. Nachr. No. 4821. Nature, 96. pp. 466–467, Dec. 23, 1915. Abstract.)—Observations on 1915 Sept. 12, 23, 28, and Oct. 4 showed variability in the star (1900 RA = 4h. 58m. 46s.; decl. = − 4° 20·8′), in Orion. The extremes of brightness were 6·4 and 8·5 magnitude. C. P. B.

175. *New Algol Variable in Corona.* **C. Hoffmeister.** (Astron. Nachr. No. 4821. Nature, 96. p. 467, Dec. 23, 1915. Abstract.)—The variability of the star B.D + 30° 2688 was discovered during Aug., 1914. Its normal magnitude is given as 9·28, minimum 9·76, period 17h. 29m. 4·18s. C. P. B.

176. *Variability of UV Persei.* **E. Hartwig, A. A. Nijland.** (Astron. Nachr. Nos. 4815 and 4818. Nature, 96. p. 466, Dec. 23, 1915. Abstract.)—A sudden maximum of this variable was recorded by Hartwig on Sept. 2, the star reaching 11 mag. although less than 13–14 mag. on Aug. 23. On Sept. 4 it was again invisible.

Nijland (in No. 4818) reports that the star could not be found on Aug. 31, while on Sept. 3 it was as bright as the comparison star, but had vanished on Sept. 4. The previous maximum occurred on 1914 June 19, 484 days earlier.

C. P. B.

LIGHT.

177. *Improved Cadmium Photometer for Ultra-violet Light.* **J. Elster** and **H. Geitel.** (Phys. Zeits. 16. pp. 405–408, Nov. 1, 1915.)—In a previous paper [Abs. 842 (1914)] a description was given of a lamp with cadmium or zinc kathode adapted for photometric measurements in the ultra-violet. The present paper describes various improvements in the apparatus, and comparison tests against a mercury lamp. Photographs of the instrument are reproduced. A. W.

178. *Transformation of Colour-mixture Equations from one System to Another.* **H. E. Ives.** (Frank. Inst., J. 180. pp. 673–701, Dec., 1915.)—The problems dealt with in this paper are (i) How can measurements on one trichromatic system be transformed to another trichromatic system? (ii) How can measurements on any trichromatic system be transferred to the monochromatic system, and *vice versa*? The material for such transformations is found in the work of Abney and of Koenig, dealing with the methods of obtaining the fundamental colour sensations. The approach to the problem is here made through what appears to be the clearest method of representing the facts of colour mixture, namely, by a space diagram, the colour pyramid. For simplicity, a few special cases only are taken; but these are sufficient to meet the practical problems of colour measurement. The paper is illustrated by numerous diagrams and should be consulted by those interested. A. W.

179. *Heterochromatic Photometry by Crova's Method.* **H. E. Ives** and **E. F. Kingsbury.** (Am. Illum. Engin. Soc., Trans. 10. pp. 716–723; Disc., 724–726, Nov., 1915.)—Crova's method of coloured light photometry consists in the observation of the photometer field by monochromatic light of such a wave-length that equality of intensity in that wave-length indicates equality of total intensity [see Abs. 754 (1911)]. It is, of course, necessary to strike a mean between true monochromatism and sufficiently high transmission, while for the purpose for which this investigation was undertaken, namely, the photometry of incandescent gas mantles, it is necessary that the transmitting solution shall have as nearly as possible the same transmission for all ordinary gas mantles, irrespective of what it may be for other illuminants. Such a solution was found by means of the physical photometer [see Abs. 62 (1916)] and upon calibration both by this instrument and by ordinary visual (flicker) methods the agreement between the two was found to be excellent and to show that the solution actually fulfilled the requirement stated above. A similar solution has been found for use with electric glow-lamps. In the *discussion*, the **Authors** stated that the solution was, so far as they could ascertain, permanent in its transmission although indications were obtained that exposure to strong light caused a temporary change. This, however, has no effect in practice as the solution is placed before the photometer eyepiece where the illumination is low. J. W. T. W.

180. *Threshold of Vision for different Coloured Lights.* **W. de W. Abney** and **W. Watson.** (Roy. Soc., Phil. Trans. 216. pp. 91–128, Dec. 6, 1915.)—Describes an investigation of the sensitivity of different regions of the retina

to light of various wave-lengths by the determination of the relative intensities at extinction of the various colours when received both on the fovea and at different distances from its centre up to 10 degrees. Fixation was obtained by means of a deep red light having little or no stimulus value for the rods. Measurements were made by 8 observers, 5 with normal colour vision, 2 dichromates, and 1 with a displaced green sensation curve. Observations were made throughout the spectrum both with central fixation and also with the fixation spot 1·25, 2·5, 5, and 10 degrees above the centre of the disc on which the stimulus light was received. The results obtained are tabulated and exhibited graphically, and show that the observers may be grouped into two classes, in the first of which (the more common of the two) the fovea is practically free from rods, and the light, just before it is extinguished at the fovea gives the sensation of colour, while in the second class, who have a more or less plentiful supply of rods at the fovea, so long as the stimulus is red, the colour is distinguishable right down to extinction, but throughout the rest of the spectrum the light loses colour a considerable time before it is extinguished. The influence of the size of the stimulus surface on the threshold value at the different parts of the retina is also considered. An arrangement is described for determining to which of the two classes above mentioned any given observer belongs. A visibility curve obtained by a normal observer (rodless fovea) is found to agree well with those of Ives [see Abs. 288B (1913)] and Nutting [Abs. 161 (1915)], except that it lies considerably lower in the blue and violet. This is explained by the fact that the authors used pure cone vision, whereas previous observers were probably using a far larger photometric field and so were dealing with mixed rod and cone sensation. A series of experiments was also made to determine the relative sensitivites of the foveal and parafoveal regions of an observer of each class. In the case of an observer with rodless fovea, the ratio of the foveal to parafoveal intensities for equal brightness is about 1·2 at long wave-lengths, and rises to as much as 27 at short wave-lengths, whereas this ratio remains between 1 and 2 throughout the spectrum for an observer having rods at the fovea. J. W. T. W.

181. *Electron Optics of the Hydrogen Molecule.* **A. Heydweiller.** (Deutsch. Phys. Gesell., Verh. 17. 17–20. pp. 359–362, Oct. 30, 1915.)—It is now shown [see Abs. 1249 (1915)] that the ionic refraction of the hydrogen kathion is approximately equal to its difference from the equivalent refraction of either the divalent magnesium kathion or the trivalent aluminium kathion. This difference amounts to about 0·15 c.cm., *i.e.* the half of the volume previously termed the fundamental "stere" for the kathion; it is therefore more accurate to take this halved volume as the fundamental stere. The stere-number of the hydrogen kathion, *i.e.* the ratio of its refraction to the fundamental stere, is thus equal to 1, while that of the divalent Mg kathion or the trivalent Al kathion, and also its refraction, is zero. The divalent Mg and the trivalent Al kathions consequently contain no electrons or, at any rate, none capable of being brought into a state of vibration by visible or ultra-violet light at the ordinary temperature. The hydrogen kathion possesses at least one electron and the hydrogen atom at least two electrons; this conclusion was also arrived at by Stark in an entirely different way [see Abs. 1667 (1915)]. T. H. P.

182. *Black Body as Light Source between* 2000° *and* 10,000° *Abs.* **A. R. Meyer.** (Deutsch. Phys. Gesell., Verh. 17. 21. pp. 384–404, Nov. 15, 1915.)—

By means of the Wien-Planck formula and the Stefan-Boltzmann law, combined with the sensitivity curve of the eye, it is possible to deduce the law according to which, for a black body, the proportion of visible to total radiation varies with the temperature. The luminous efficiencies deduced for the ordinary radiators (allowing for conduction and other losses) are as follows:—

Radiator.	Efficiency. Watts per Mean Hefner Candle.	Proportion of Visible Radiation, Per Cent.
Carbon filament lamp	3·5	1·9
Tantalum filament lamp ...	1·6	3·3
Tungsten filament lamp ...	1·1	5·0
Gas-filled lamp	0·55	11·2

J. W. T. W.

183. *Sensitometry of Process Plates.* **C. E. K. Mees.** (Eastman Kodak Co.'s Research Lab., Sci. Publ. pp. 9–10, 1913–1914.)—The system of sensitometry which has been developed for the investigation and classification of photographic products, and especially for the determination of the sensitiveness and gradation of photographic plates, depends upon the relation which exists between the exposure undergone by the plates and the density of the silver deposited by development. As plates are ordinarily used to render a long scale of light intensities by a similar scale of deposits of silver, the sensitiveness, as usually determined, depends upon the rendering of the middle portion of this scale, and if the sensitiveness is to be read from the density corresponding to a given exposure, the development must also be fixed as that required to produce a correct gradation. But there are only two tones in a good process negative, namely: clear glass and absolutely opaque deposit. In half-tone negatives the gradation is rendered by various sizes of dot and not by various densities; the negative again contains only two tones, clear glass and opaque deposits. This being so, a plate which will give the necessary opacity to the high lights of a line negative or the dots of a half-tone negative with less exposure than another plate, is effectively faster without regard to any question of gradation. For line photography such an exposure must be given as will just not produce a deposit on the lines, and this will be half the inertia of the plate. Now, if the drawing be considered to have 5 % reflecting power in the lines of the light reflected from the high lights, then if the exposure to the lines be half the inertia, the high lights will receive 10 times the inertia, and the density will therefore be numerically equal to the max. contrast (Gamma infinity) which the plate will give. If the max. contrast in the subject is low, the exposure is governed by the max. exposure which can be given if the dark areas of the copy are to be rendered as clear glass in the negative, and since that max. exposure is proportional to the inertia, the rated "H. and D." sensitiveness holds. If, however, the max. contrast is high, the exposure is governed by the minimum exposure necessary to get sufficient density in the opaque areas which is settled by the max. contrast obtainable, and this "H. and D." sensitiveness no longer holds. A. E. G.

184. *Satista and other Platinotype Papers.* **W. H. Smith.** (Phot. J. 55. pp. 282–286, Dec., 1915.)—Japine silver print-out paper is manipulated in almost the same way as any other printing-out paper. An exception is that

in this case there is no gelatine or anything that can rub off the paper or that can be affected by hot water, and the paper will stand almost any amount of rubbing without fear of abrasion. The prints lie flat in the water, and can be dried between blotters or in front of the fire. The solutions can be used cold or warm. So far as depth of printing is concerned, it is not necessary to print quite so deeply as with ordinary printing-out paper. One little difference between this paper and some others of its kind is that it is sent out dry, and should be allowed to get a little damp by exposure to the atmosphere before printing. If quite dry, the printed image comes out a bluish colour, whereas it should be more of a reddish tone, and this is got by allowing the print to absorb a little moisture. An hour or two is usually quite sufficient, but some professionals leave the paper all night. If printed too dry the paper tones too flat. The paper tones very freely, and evenly, from a red brown to a warm black, according to time of immersion and composition of toning bath. For platinum toning the prints after exposure should be washed to get rid of all free silver. The prints may also be toned and fixed in a combined bath of hypo and gold.

The Satista process is due to Willis, the inventor of platinotype. He found that paper coated with silver chloride and ferric oxalate would give only a feeble image when exposed to light under a negative and developed in oxalate of potash, but that by addition of a small quantity of a salt of platinum to the ferric oxalate, the paper would give very fine black prints closely resembling platinotype. A print on Satista paper has very much the appearance of platinum. Actually the high lights are formed of platinum, so that a picture with very delicate tones will be composed almost entirely of platinum with very little silver. In a Satista print the essential parts of the picture are in platinum, and in the shadows the silver is in the best form for permanence. The development of the image is done with oxalate of potash, the same as for platinotype. The clearing bath for Satista is an almost saturated solution of binoxalate of potash, about 1¼ oz. being dissolved in 80 oz. of water. The prints are cleared in this solution and then washed for a few minutes. After clearing they have to be fixed in hypo.

Some advantages of platinotype paper are also dealt with, and experiments showing how results may be varied are described. A. E. G.

185. *Calculation of Exposure.* **C. E. K. Mees.** (Eastman Kodak Co.'s Research Lab., Sci. Publ. pp. 11–14, 1913–1914. Abstract.)—A film which is correctly exposed is one which is exposed so that the deepest shadows in the subject will be rendered by a just visible trace of deposit. If the brightness of a typical sunlit landscape is measured with a photometer, it will be found that the sky will have a brightness of about 8000 candle-ft., the deepest shadows in dark tree-trunks in the foreground having an intrinsic brightness of about 100 candle-ft. It can be shown by calculation that making allowance for reflection and absorption, and disregarding, as has been done in all these calculations, the ultra-violet light which is strongly absorbed by glass, the brightness of the image with a stop of $f/8$ is very nearly 1/100 of the brightness of the object, so that the range of intensities in the camera image of a typical sunlit landscape is from 1 to 80 candle-ft. using $f/8$, and if we give an exposure of 1/100 sec. we shall get a range of exposures of from 1/100 to 8/10 candle-ft. seconds. This exposure will apply only to a very rapid film or plate, one of the type termed "ultra rapid," and assigned a speed of about 500, so that if we take the speed of the plate or film into account we can see that for a film of speed 500 at $f/8$ we shall require an exposure of

1/100 sec. if the light reflected from the darkest portion is about 100 candle-ft. If the light reflected from the darkest shadow of the object were 1 candle-ft., we should require an exposure of 1 sec. on a film of speed 500, or 500 secs. with a film of speed unity, or, generally, if L is the light intensity from the darkest part of the subject, P the speed of the film or plate and E is the exposure at *f*/8, then $E = 500/LP$, E being expressed in seconds, L in candle-ft., and P in the usual speed units. Calculating in this manner it can be seen that the shortest exposure possible for figures in rapid motion, using bright sunlight and the most rapid lens with the latest film available, an exposure of about 1/500 sec. is the shortest time which can be given to get full exposure. Other examples are :—Landscape work with a panchromatic plate and K_3 filter, for which at *f*/8 and sunlight the exposure will be about 1/15 sec. ; the exposure for three-colour work, using a wide-open lens at *f*/4·5, will be about 1/12 sec., while the shortest exposure that will be necessary in a brightly lighted theatre will be about 1/10 sec. A. E. G.

186. *Action of Light and of X-rays on the Photographic Plate.* **J. K. A. W. Salomonson.** (K. Akad. Amsterdam, Proc. 18. Nos. 4–5. pp. 671–682, 1916.) —In a series of experiments on the quantitative action of light and of X-rays on photographic plates, the author finds a characteristic difference between the two kinds of rays. The sensitive layer of the plate strongly absorbs light, whereas X-rays are only slightly absorbed. In the case of X-rays which are not notably weakened after passing through the silver-bromide emulsion, the action on the deeper layers is comparable with that on the surface, whereas in the case of light the strong action is confined to the surface layers with a markedly diminishing effect on the lower strata.

A simple theory is given for these effects, and photomicrographs are shown in illustration. A. B. W.

187. *Refraction of Finite Wave-trains at a Plane Surface.* **A. Landé.** (Ann. d. Physik, 48. 4. pp. 521–545, Nov. 9, 1915.)—A mathematical treatment of the subject, based on Sommerfeld's general solution. [See also Abs. 1250 (1915).] A. W.

188. *Mutual Action between Two Electric Doublets and Rotation of Plane of Polarisation in Crystals and Liquids.* **C. W. Oseen.** (Ann. d. Physik, 48. 1. pp. 1–56, Sept. 28, 1915.)—Highly analytical discussion from which it is concluded that the effect of the mutual action between resonators in the same molecule on the propagation of light may be qualitatively expressed as a rotation simply of the plane of polarisation, *i.e.* that in every direction two circularly polarised waves may be propagated with different velocities. The rotation in an active mixture is not the simple sum of the separate rotations due to the active components. E. H. B.

189. *New Form of Nephelometer.* **J. W. T. Marshall and H. W. Banks.** (Am. Phil. Soc., Proc. 54. pp. 176–184, May–July, 1915.)—A new form of nephelometer is described in which columns of suspension of equal lengths are used. The lights reflected are equalised and compared by means of a movable wedge of neutral-tinted glass. Juxtaposition of the two emergent beams is secured by mirrors. L. H. W.

190. *Theories of the Latent Image and Reversal.* **E. P. Wightman.** (J. Phys. Chem. 19. pp. 571–588, Oct., 1915.)—A preliminary introduction to some experimental work on reversal, not yet carried out. L. H. W.

191. *Searching for a Reason for Eye Fatigue.* **M. Luckiesh.** (El. World, 66. pp. 576–578, Sept. 11, 1915.)—Shows, among other things, how the density of energy varies within the eye. L. H. W.

192. *Polariser in Petrographic Microscope.* **F. E. Wright.** (Washington Acad. Sci., J. 5. pp. 641–644, Dec. 4, 1915.)—In petrographic microscopes the polariser is mounted in one of two positions, so that its plane of light-transmission is parallel either to the vertical or to the horizontal cross-hair of the eyepiece. Some makers prefer one position, some the other; but appear to have no particular reason for their choice. An extended series of tests with the petrographic microscope has shown that for an observer using light from the northern sky, the correct position depends on the time of day at which observations are made. If on a clear day the observer wishes to get max. illumination, it is necessary to set the plane of the polariser parallel to the vertical cross-hair in the early morning or late afternoon, while in the middle of the day it is best in the horizontal position. The polariser is, however, commonly fixed in position; in view of the fact that at noon there is always an abundance of light from a clear sky, while in the early morning and late afternoon the sky illumination is less than half that at noon, the position of the polariser which favours greater intensity of illumination at early and late hours is to be preferred as the fixed position. In this position the plane of vibration of the rays emerging from the polariser is parallel to the vertical cross-hair of the eyepiece. On cloudy and misty days the amount of sky polarisation decreases rapidly and is practically negligible. On such days, consequently, the position of the plane of the polariser has little effect on the intensity of the field illumination in the microscope. A. W.

193. *Absorption Spectra of the Vapours of Inorganic Salts.* **E. J. Evans.** (Phil. Mag. 31. pp. 55–62, Jan., 1916.)—The author has investigated the absorption of the vapours of ammonium chloride, mercuric and mercurous chlorides, cadmium chloride, bromide and iodide in the region $\lambda 2500$–$\lambda 6700$ Å.U. With the exception of NH_4Cl all exhibit, in the ultra-violet, general absorption only, which extends redwards on raising the temperature of the vapour. Ammonium chloride has practically no absorption, and in the case of the cadmium halides the absorption increases on passing from the chloride to the iodide. The vapours were produced by placing the solids in quartz tubes, which were subsequently evacuated and heated in an electric furnace over a range extending from room temperature to 1000° C. The spectra were examined visually and photographically, using a 1-m. radius grating and a carbon-arc light source. C. S. G.

194. *Conditions for a Bright Hydrogen Spectrum, especially Line* 4341 *Å.U.* **J. Guild.** (Phys. Soc., Proc. 28. pp. 60–71; Disc., 72, Dec., 1915.)—An important paper dealing with practical methods for the production of a bright hydrogen spectrum, and especially of G′, line 4341 Å.U., such as is required for refractometry and similar purposes. The rapid deterioration of hydrogen tubes is shown to be due to the rise of pressure caused by the evolution of hydrogen from the electrodes. This trouble is obviated by sealing to the discharge tube an auxiliary bulb, 70 to 100 times its capacity. With such an arrangement the life of the tube was found to be increased nearly a hundred-fold, and the discharge had a constant character under heavy excitation for considerable periods. Large currents can only be used,

without fear of cracking the tube, over a range of 1 to 8 mm. pressure—that is, over the range in which the max. intensity is obtained in a new tube. Inductance and capacity can be utilised beneficially with deteriorated tubes, but these variants are ineffective at pressures below 1 cm. Gaseous impurities are of little importance with the exception of mercury vapour, and to avoid this the author recommends the use of an oil pump without a gauge. Mercury-contaminated tubes should be cleaned out by washing with strong nitric acid.
C. S. G.

195. *Radiation from an Electric Source, and Line Spectra.* III. L. **Silberstein.** (Phil. Mag. 30. pp. 784–805, Dec., 1915.)—A continuation of previous work [Abs. 850 and 1040 (1915)]. Theory is first given dealing with the case of large permittivity, when the source shrinks to molecular dimensions. Suggestions are then put forward as to the possible process of excitation of line spectra, and it is shown that a variation in the radius of the source of about one part in 4×10^9 would be sufficient to account for max. emission. Dispersion is next dealt with, after a few generalities have been given on the distribution of spectral lines. An investigation is given of the chief consequences of assuming the particular form of dispersion $k = k_0 + \sum_{i=1}^{i=k} b_i/(\lambda^2 - \gamma_i^2)$ which is called the typical form of atomic dispersion. When there is only one convergence point the formula is simplified into $k = \beta\lambda^2/(\lambda^2 - \gamma^2)$, and the corresponding simple series is found to approach Balmer's law asymptotically with increasing values of i. It is then shown that this simple series represents fairly well the higher members of the observed diffuse series of hydrogen from H_{35} down to H_{14}, with a difference not much exceeding 0·5 Å.U., and generally much smaller. For the remaining lines, H_{13} to H_1, the differences between the observed and calculated wave-lengths mount up with increasing rapidity. The principal series of Na and Li can also be represented by means of the "simple series" formula, fairly good agreement being obtained between the observed and calculated values for the wave-lengths as far as $i = 4$. The coexistence of two or more "simple series" offers some points of interest, and will be considered in the next paper, in which also the lower members of the spectral series will be dealt with.
A. W.

196. *Structure of the Mercury Triplet* λ3663, 3655, 3650. **T. Takamine.** (Math. Phys. Soc., Tōkyō, Proc. 8. pp. 309–315, Nov., 1915.)—This triplet was first studied by Janicki [Abs. 1878 (1909)], but the only thorough investigation hitherto published of the structure of the ultra-violet mercury lines is that of Wendt [Abs. 867 (1912)]. As Wendt used a concave grating only, the discrimination of ghosts is of some difficulty, especially for faint lines. In the present work the lines were studied by means of a 35-step echelon and also by a quartz Lummer-Gehrcke plate. Photographs are reproduced, and tables and diagrams are given showing the results obtained by Janicki, Wendt, and the author. The line which has shown a considerable difference in structure from the results previously obtained is λ3650. There are four components of gradually decreasing intensity at nearly equal intervals on the negative side of the principal line. This gradual decrease of intensity among the satellites of mercury lines has previously been noted by Nagaoka and the author. In the present case, the feature is evident at a glance, but photometric measurements will be necessary for obtaining the quantitative relations.
A. W.

197. *Comparison of the Positive Rays with the Spectrum of the Positive Column in a Mixture of Helium and Hydrogen.* **H. Smith.** (Phil. Mag. 30. pp. 805–811, Dec., 1915.)—The research here described was undertaken to compare the spectra of various mixtures of helium and hydrogen with the relative intensity of the positive rays of the same mixture. As a large proportion of He is necessary before its spectrum appears, it would be possible to observe whether the positive rays of He appeared just when the same proportion was present. If there were a direct connection between the spectrum of He and its positive rays in this manner, it would be a strong argument for supposing that a gas whose spectrum is completely masked takes no part in the discharge. The apparatus used was of the usual type employed for producing positive rays, and was so arranged that mixtures of hydrogen and helium in various proportions could be introduced into the discharge bulb. The photographs of the spectrum in residual air when the pressure is sufficiently low to give good photographs of the positive rays, show the mercury lines strongly and the negative band of nitrogen at λ3914. The positive bands and the line spectrum of nitrogen could not be observed, nor did any of the spectra of oxygen appear. The positive rays, besides showing the lines due to the hydrogen atom and molecule, also show the line due to air very strongly. Other work has shown that the oxygen line is frequently stronger than the nitrogen line. The lines due to the molecules of oxygen and nitrogen also occur. Thus while we get the positive rays of atomic oxygen and nitrogen in residual air, as well as the lines due to their molecules, we get only one of the spectra of molecular nitrogen present in the light from the positive column. In this case no connection can be traced between the positive rays and the spectrum of the gaseous mixture. In the helium and hydrogen experiments the proportion of He was varied from 60 % down to 2 %. At the higher value the spectrum of He was just as strong as that of hydrogen, but in a series ranging from 30 % down to 2 % He not a trace of the He spectrum appeared. In the positive-ray photographs He was not detected at a smaller proportion than 10 %, although here the line due to it was as strong as that due to the hydrogen molecule. In a final experiment, where the proportion of He was too small to be estimated, a positive-ray photograph showed a faint He-line. It thus appears that the He spectrum disappears at a much earlier stage than the helium positive rays, which are remarkably persistent. It would seem that a gas, whose spectrum in the positive column is more or less completely masked by the spectrum of the gas with which it is mixed, may still be taking a very important part in carrying the current in the dark space. It is doubtful, however, whether this conclusion can be carried further so as to include the positive column.

A. W.

198. *Excitation of Phosphorescence by Canal Rays.* **E. Rüchardt.** (Ann. d. Physik, 48. 6. pp. 833–876, Dec. 7, 1915.)—From the results of further experiments [see Abs. 429 (1913), 453 (1915)] conclusions are drawn concerning the distribution of energy in the electric spectrum of the canal rays of hydrogen, the influence of the charge of the canal rays on the efficiency in the excitation of phosphorescence, and the dependency of the intensity of phosphorescence on the energy of the canal rays.

T. H. P.

199. *Preparation of Phosphorescent Calcium Sulphide.* **P. Breteau.** (Comptes Rendus, 161. pp. 782–783, Dec. 13, 1915.)—According to Verneuil (Comptes Rendus, 104. p. 501, 1887), calcium sulphide showing vivid phosphor-

escence is obtained by heating to bright redness in a Perrot furnace an intimate mixture of calcium carbonate, sulphur, sodium carbonate and chloride, and bismuth subnitrate. The author finds that the sodium carbonate and chloride are not indispensable, that heating to bright redness in a Perrot furnace is disadvantageous, and that it is preferable to prepare the calcium sulphide beforehand. Phosphorescent calcium sulphide may indeed be obtained by heating the salt, impregnated with bismuth, with 1 % of its weight of sodium sulphide. T. H. P.

200. *Photographic Measurement of the Hardness of X-rays.* **J. K. A. W. Salomonson.** (Phys. Zeits. 16. pp. 389–391, Nov. 1, 1915.)—F. Voltz, discussing this question [see Abs. 1767 (1915)], came to the conclusion as a result of his experiments that the photographic method of estimating the penetrating power of X-rays was insufficient and unreliable. The author disagrees with Voltz's conclusions and criticises his observations. In his experiments Voltz employed an electrostatic voltmeter to measure the average p.d. applied to the X-ray tube. The author criticises this point, and concludes that it is only permissible to use an electrostatic voltmeter for this purpose if the following conditions are fulfilled: (1) permanent static charges must be avoided, (2) non-intermittent uni-directional current must be used, and (3) the variations in this current must be fairly small.

From general considerations of this kind, the author concludes that for all practical cases which are likely to arise, the photographic method of measuring "hardness" is quite sufficient. A. B. W.

201. *Optics of X-rays.* **G. Gouy.** (Comptes Rendus, 161. pp. 765–767, Dec. 20, 1915.)—A discussion of the problem of the focusing of X-rays, making use of crystalline reflection. The possibility of this, with the consequent possibility of the formation of sharp X-ray images is of great importance in X-ray spectroscopy. Considering first of all the case of reflection of X-rays from a crystal having parallel and equidistant planes of atoms, the author extends the reasoning to the case of reflection from a series of parallel curved planes of atoms—such as is practically realised in a slightly bent sheet of mica. The following relation, for the distance (x) of the image to the source, is given for homogeneous X-radiation:—

$$1/\lambda = n/4\mathrm{R}d \,.\, \sqrt{(x^2 + 4\mathrm{R}^2)},$$

where R is the radius of curvature of the cylinder on which the thin mica sheet is laid. A. B. W.

202. *Canal Rays.* **T. Retschinsky.** (Ann. d. Physik, 48. 4. pp. 546–576, Nov. 9, 1915.)—A continuation of previous work [Abs. 1407 (1915)] dealing with the electromagnetic and spectral analysis of canal rays. The arrangement of the apparatus was the same as that employed in the energy measurements. The results of the research are illustrated by a number of interesting diagrams and tables. (1) It is found that particles of the same velocity are deflected both by magnetic and electric fields and give rise to the displaced line in the Doppler-effect. (2) Raising the pressure in the observation space increases the number of slow-moving atoms, a corresponding reduction in the number of molecules being observed. (3) The presence of hydrogen reduces the number both of the slow-moving atoms and of the molecules. The results (2) and (3) are explained on the supposition that the atoms are due to dissociation of the molecules, and that the quick-moving atoms correspond to the discharge space, the slow-moving atoms to the observation

space. (4) The results of the electromagnetic analysis show that in oxygen the atoms are the carriers for the spark lines, while the molecules are the carriers for the series lines. (5) With gases of different atomic weight the same conditions exist in front of the kathode. An equal percentage of the number of the particles pass through each part of the whole kathode-fall. Different particles possess the same energy conditions but different velocities. The conclusion therefore is that the breadth of the displaced lines in the Doppler-effect is inversely proportional to the square root of the atomic weight. [See also Abs. 600 (1918).] A. W.

RADIO-ACTIVITY.

203. *Charge carried by Recoil Atoms from Radio-active Substances.* L. **Wertenstein.** (Comptes Rendus, 161. pp. 696–699, Dec. 6, 1915.)—It is well known that recoil atoms, produced when α-particles are expelled from radio-active substances, carry a positive charge. This was first proved by experiments of Makower and Russ on the deflection of these recoiling atoms in electric and magnetic fields. This problem of the charge carried by recoil atoms is of considerable theoretical importance, for its solution is essential for the development of our theories of the mechanism involved in the production of α-rays. It is also of importance from an experimental standpoint, for the charge carried by recoil atoms constitutes a source of error in the determination of the charge carried by the α-particle. For these reasons the author has made an experimental investigation of the question of the charge of recoil atoms, by the direct method, *i.e.* by the receiving-cylinder method. Use has been made of the extreme absorbability of recoil atoms in matter, to separate the effect of these particles from the effect of the α-particles. Three sets of observations on the charge communicated to the receiver give the required information: (1) When both α-rays and recoil-atoms pass through a high vacuum only, (2) when the recoil-atoms are filtered out from the α-rays by means of a thin leaf of Al 0·7 μ in thickness, and (3) when both recoil-atoms and α-particles are stopped by a layer of Al 0·05 mm. in thickness. The whole apparatus is placed in a strong magnetic field, and a series of experiments made at varying pressures (all very low) of the gas in the apparatus.

It is shown that in the best vacuum obtainable by means of a Gaede molecular pump, *i.e.* a pressure equivalent to 0·6 dyne/cm.^{2}, atoms of RaD recoiling from RaC *carry no electric charge.* As the pressure of the gas increases they acquire a positive charge which gradually increases, eventually becomes equal to, and then exceeds, the value of the charge carried by the α-rays.

The atoms of RaD are not charged at the instant of their production.

A discussion of the results quoted above is given, and the views are extended to the case of other radio-active transformations. A. B. W.

204. *Attempt to Influence the Rate of Radio-active Transformations.* I. **J. Danysz** and **L. Wertenstein.** (Comptes Rendus, 161. pp. 784–787, Dec. 20, 1915.)—After a short discussion of the numerous futile attempts to accelerate or retard the rate of decay of radio-active products, a set of experiments are described in which the radio-active forces themselves are employed to attain this object. Whilst such conditions as high or low temperature, compression, electrical discharge, magnetic fields, etc., have been quite ineffective, the authors thought it possible that by employing exceptionally

great atomic shocks, such as those produced by impact of α-rays, to observe some indication of a change in rate of decay of the substance bombarded.

It is concluded that even the most intimate encounters of α-particles with the atoms of the substance are powerless to induce artificial radio-activity or influence the rate of disintegration. A. B. W.

205. *Radio-active Fluctuations—using Unsaturated Currents.* **A. Ernst.** (Ann. d. Physik, 48. 7. pp. 877–906, Dec. 21, 1915. Dissertation, Tübingen.) —Apart from the exponential decay, the intensity of the radiation from a radio-active substance is not absolutely constant, but exhibits irregular fluctuations, so-called Schweidler-variations. These irregularities in the intensity of the radiation have been investigated by numerous observers, including Kohlrausch, E. Meyer, and E. Regener [Abs. 626 (1908)], and H. Geiger [Abs. 926 (1908)]. A new method is now described. By eliminating systematic errors from a large series of fluctuation-observations it is shown that the fluctuations are such as are expected according to ordinary laws of probability. The measurements of Kohlrausch on the variation of the percentage fluctuation of a radio-active preparation with the ionisation-current produced have been repeated. A. B. W.

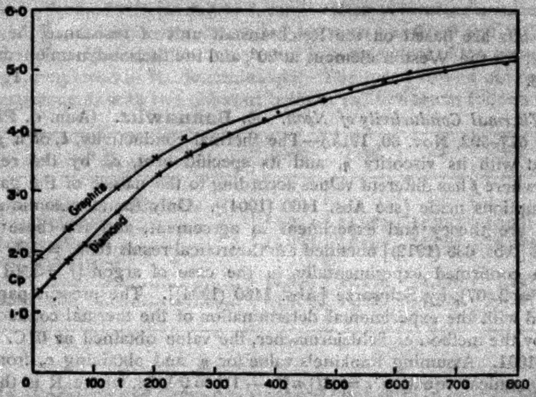
206. *Theory of β-rays.* **H. T. Wolff.** (Phys. Zeits. 16. pp. 416–419, Nov. 15, 1915.)—A theoretical discussion, in which Rutherford's model of the atom, having a positive nuclear charge, is taken as basis [see Abs. 184 (1915)]. A. B. W.

207. *Radium-Uranium Ratio in Carnotites.* **S. C. Lind** and **C. F. Whittemore.** (Bureau of Mines, Techn. Paper, 88. [28 pp.], 1915. Chem. News, 113. pp. 79–81, Feb. 18, 1916. Abstract.)—The paper commences with a lengthy introduction referring to the work of other investigators and to the various methods employed in determinations of this character. The variations of the uranium radium ratio in minerals, other than pitchblende, are discussed, and the case of carnotites is examined in detail. The authors summarise as follows:—(1) Samples of carnotite representing large quantities of ore (a few hundred lbs. to several tons) show a radium-uranium ratio identical with that of pitchblende ($3{\cdot}33 \times 10^{-7}$); this ratio is also in accord with the value calculated from radiation data. (2) Samples from small quantities of ore (hand specimens up to a few lbs.) tend to exhibit abnormal ratios. In one instance the ratio was as low as $2{\cdot}48 \times 10^{-7}$, and in another as high as $4{\cdot}6 \times 10^{-7}$. (3) The most plausible explanation for these abnormal ratios seems to be that of transposition of radium within the ore bed, producing local differences which are equalised in large samples. (4) The "emanating-power" of carnotite is high, and varies from 16 to 50 %. (5) In order to obtain concordant results by the Boltwood emanation method it was found desirable to determine the emanation liberated by solution in the same sample from which the emanating-power had just been determined, thus making the two determinations strictly complementary. (6) Radium may be easily determined in one operation by the emanation method, either by solution or by ignition from tubes in which it has been sealed for one month to reach equilibrium. (7) In contrast with the success of the solution and the ignition methods for de-emanating carnotite, the method of fusion with sodium and potassium carbonates and the fusion-and-solution method both gave low results and were abandoned.

The paper contains the details of the analysis of 24 samples of different minerals, a table of results for numerous specimens of carnotite being also included. A critical discussion of these results follows. A. B. W.

HEAT.

208. *Specific Heat of Platinum and of the Diamond at High Temperatures.* **A. Magnus.** (Ann. d. Physik, 48. 7. pp. 983–1004, Dec. 21, 1915.)—The only measurements of the specific heat of the diamond at high temperatures were made by Weber in 1875. On account of its simple space-lattices [Abs. 1881 (1914)] an exact determination is necessary for theoretical purposes. Weber, in his investigation on graphite and the diamond, did not measure his high temperatures directly, but deduced them from the amount of heat given up by Pt when cooled through the same range of temperature. The author therefore employs, with a few modifications, the large calorimeter already described [Abs. 625 (1913)] in order to determine the specific heat of pure Pt between air temperatures and 900° C. The results may be represented by the equation, $C_p = 0{\cdot}03159 + 5{\cdot}8468 \times 10^{-6}t$, this equation being applicable at any rate within the range 150° to 850° C. The specific heats of diamond and graphite are then re-calculated from Weber's figures. The curves above are deduced from the results. T. B.



209. *Specific Heat of Water between 5° and 50° in International Watt-seconds.* **W. Jaeger and H. v. Steinwehr.** (Deutsch. Phys. Gesell., Verh. 17. 17–20. pp. 862–868, Oct. 30, 1915. From the Physikal.-Techn. Reichsanstalt.)—The author's measurements were made with a closed, cylindrical copper calorimeter holding 50 litres and surrounded by a water-jacket kept at a definite temperature by means of circulating water. The temperature was measured with a Pt thermometer, the energy being determined by measuring the current and voltage by means of a compensation apparatus. A series of 66 measurements were made at approximately regular intervals between 5° and 50°, the mean error being about $8{\cdot}5 \times 10^{-4}$. For the heat-capacity A the formula $A_u = 4{\cdot}2047, - 0{\cdot}001768u + 0{\cdot}00002644,u^2$, is deduced, u being the temperature in Centigrade degrees. The results are summarised in the following table :—

u.	A.	$A : A_{15}$.	Temp.-coeff. × 10^{-4}.
5°	4·1966	$1·0029_5$	− 3·58
10	$4·1897_5$	$1·0013_5$	− 2·96
15	4·1842	1·0000	− 2·34
20	4·1800	0·9990	− 1·70
25	4·1771	0·9983	− 1·07
30	4·1755	0·9979	− 0·43
35	4·1753	$0·9978_5$	+ 0·20
40	4·1764	$0·9981_5$	+ 0·83
45	4·1788	0·9987	+ 1·47
50	4·1825	0·9996	+ 2·10

These results are based on the Reichsanstalt unit of resistance, the value 1·0183 volt for the Weston element at 20°, and the thermodynamic temperature-scale. T. H. P.

210. *Thermal Conductivity of Neon.* **E. Bannawitz.** (Ann. d. Physik, 48. 5. pp. 577–592, Nov. 30, 1915.)—The thermal conductivity, k, of a gas is connected with its viscosity η, and its specific heat, c_v, by the relation $k = f\eta c_v$, where f has different values according to the nature of the gas and the assumptions made [see Abs. 1460 (1904)]. Only for monatomic gases, however, are theory and experiment in agreement, and for these gases Chapman [Abs. 686 (1912)] obtained the theoretical result that $f = 5/2$. This has been confirmed experimentally, in the case of argon ($f = 2·501$) and helium ($f = 2·507$), by Schwarze [Abs. 1460 (1904)]. The present paper is concerned with the experimental determination of the thermal conductivity of neon by the method of Schleiermacher, the value obtained at 0° C. being $k = 0·0001091$. Assuming Rankine's value for η, and obtaining c_v from the thermodynamical equation $c = R/[m](x - 1)] = 0·1474$, where R is the gas constant, m the molecular weight, and x the ratio of the specific heats, the author verifies Chapman's theory in the case of neon, the value of $f = k/\eta c_v$ being 2·501. T. B.

211. *Thermal Resistance at the slightly Conical Junction of Two Solids.* **T. Barratt.** (Phys. Soc., Proc. 28. pp. 14–20, Dec., 1915.)—In order to verify the validity of certain assumptions made in his previous experiments on the thermal conduction of solids [Abs. 1991 (1914), 816 (1915)] the author has investigated the fall of temperature at a junction of two metals through which heat is passing. The conical extremity of a solid rod was fitted, as accurately as possible, into a hole bored into a solid copper cylinder heated electrically, and the rest of the rod projected into a constant-temperature air enclosure. Measurements were made with the cylinder at various temperatures up to 100° C. but the temperature of the enclosure was never more than 10 or 12 deg. C. below that of the rod. It was found that at the junctions of various metals of comparatively high conductivity and small diam. (1 mm.) the fall of temperature was constant and about 2¼ % of that of the cylinder, while it was rather less in the case of thicker rods (6-mm.) made of metals of low conductivity. The thermal resistance is probably due to the thin air film between the surfaces, and it is slightly reduced by smearing them with olive oil. D. O. W.

V.
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212. *Measurement of very Low Temperatures.* **XXVI.** *Vapour Pressures of Oxygen and Nitrogen according to v. Siemens' Pressure Measurements and Onnes' Determinations.* **G. Holst.** (K. Akad. Amsterdam, Proc. 18. Nos. 4–5. pp. 829–839, 1916. Comm. No. 148*a* from the Phys. Lab., Leiden.)—The calibration of v. Siemens' Pt-resistance thermometer [see Abs. 269 (1914)] in terms of the Leiden standard thermometer by means of Nernst's linear reduction formula does not agree so well with later calibrations as do the latter among themselves, considerable deviations occurring, especially in the oxygen region. Correction of v. Siemens' temperatures leads to new tables giving the vapour pressure of oxygen from 90·21° K. to 57·40° K. and those of nitrogen from 80·48° K. to 57·00° K. T. H. P.

213. *Wien-Planck Radiation Constant.* **E. Warburg and C. Müller.** (Ann. d. Physik, 48. 3. pp. 410–432, Oct. 29, 1915. Comm. from the Physikal.-Techn. Reichsanstalt.)—A continuation of former work [see Abs. 640 (1913)]. Experiments over the region between λ = 0·589 and 2·172 μ show that the Wien-Planck radiation constant is independent of the wave-length of the light employed in its determination. The mean results obtained in the new experiments with two different types of raditors are as follows :—

λ =	0·5893.	1·132.	1·588.	2·172.	Mean.
Lummer-Kurlbaum Radiator—					
Small Model	14,249	14,262	14,255	14,251	14,254
Large Model	14,288	14,263	14,288	14,288	14,279
Carbon Radiator—					
1675° abs.	14,278	14,168	14,198	14,227	14,217
2245° abs.	14,268	14,195	14,226	14,257	14,287

J. W. T. W.

214. *Radiation and Convection from a Heated Wire in an Enclosure of Air.* **T. Barratt.** (Phys. Soc., Proc. 28. pp. 1–12; Disc., 13 Dec., 1915.)—Contains an account of experiments made in order to determine the numerical relation between the heat lost by radiation and by convection from a hot wire placed in an enclosure, containing air at atmospheric pressure, whose walls are maintained at constant temperature. The apparatus employed was that used by the author in his experiments on thermal conductivity [Abs. 1991 (1914)]. The method consisted in (1) measuring the amount of heat required to maintain the temperature of the wire a given amount above that of the surrounding gas, the surface of the wire being (*a*) coated with a dead-black varnish, (*b*) uncoated; (2) comparing the radiations from two surfaces of a Leslie cube similar to (*a*) and (*b*) by means of a thermopile. Wires of different substances were used and the results obtained from both (1) and (2) were found to be independent of the material of the wire. The diameters varied from 1 to 6 mm. ; the excess temperature was of the order of 10 deg. C., and experiments were carried out at room temperatures and at 100° C.

The experiments indicate that of 100 parts of "total heat" lost from a wire at air temperatures, 2·5 consist of radiation for a bare wire, and 12·6 for a blackened wire. At 100° C. these percentages become 4·4 and 20·7 respectively, being the same for all diameters tested. The actual increase of total loss when the temperature increased from 17° to 100° was 20 %, and it is thus largely due to increased convection. The coefficient of total emissivity decreases as the diam. increases, being, at 18° C., equal to 0·00058 for a wire 1 mm. in diam. and 0·00022 for another 6 mm. in diam. D. O. W.

215. *Second Virial Coefficient for Rigid Spherical Molecules, whose Mutual Attraction is Equivalent to that of a Quadruplet placed at their Centre.* **W. H. Keesom.** (K. Akad. Amsterdam, Proc. 18. Nos. 4–5. pp. 636–646, 1916. Supplement No. 39*a* to Communications from the Phys. Lab., Leiden.)—From the results of Debye's investigations on dielectric constant and refractive index [see Abs. 571 (1912)], it is evident that the molecules of the diatomic elementary gases do not possess a moment such as that of a doublet. In the theoretical considerations of the present paper the molecules are regarded as rigid spheres of concentric structure having at their centre a quadruplet composed of two doublets, which have axes in the same line but of opposite directions and approach one another indefinitely, preserving, however, a finite quadruplet-moment. For such a system of rigid spherical molecules the second virial coefficient, B, is developed in a series of ascending powers of T^{-1}. The values of B for hydrogen from −100° to +100° C. are represented with sufficient accuracy by the equation thus deduced.
T. H. P.

216. *Two Theorems concerning the Second Virial Coefficient for Rigid Spherical Molecules, which beside Collisional Forces exert only Coulomb Forces and for which the Total Charge of the Active Agent is Zero.* **W. H. Keesom.** (K. Akad. Amsterdam, Proc. 18. Nos. 4–5. pp. 868–871, 1916. Supplement No. 39*b* to Communications from the Phys. Lab., Leiden.)—In calculating the second virial coefficient, B, in the equation of state written in the form, $pv = RT(1 + B/v + C/v^2 + \ldots) \ldots (1)$ for a system of rigid spherical molecules carrying a doublet at the centre [see Abs. 1856 (1912), 644 (1913)], the second term in the development according to inverse powers of the temperature, $B = B_\infty (1 + b_1/T + b_2/T^2 \ldots) \ldots (2)$ did not occur, and this was also the case with all the higher odd powers. With rigid spherical molecules carrying a quadruplet of revolution type [see preceding Abs.], the second term in (2) was again absent, but the higher terms with b_3, etc., present. It is now shown that in the development of B the term containing T^{-1} does not occur if the following conditions are fulfilled: (*a*) The molecules behave at their collisions as rigid spheres; (*b*) the attractive or repulsive forces—not including the collisional forces—which the molecules exert on each other originate from fixed points in the molecule and can be derived from a Coulomb law of force (inversely proportional to the square of the distance between the attracting or repelling points), so that these forces might be ascribed to an electric agent possibly with multiple points; (*c*) the total quantity of the agent in each molecule is zero, the molecules being electrically neutral. No odd power of T^{-1} occurs if, in addition, (*d*) the molecule possesses, as regards its attractive and repulsive forces, at least one axis of "inverse symmetry," that is, if each volume element contains a quantity of the agent equal and opposite to that of the volume element with which it coincides after a revolution about that axis through the angle, $2\pi/K$, K being a whole and necessarily even number.
T. H. P.

217. *Investigation of the Equilibrium, Liquid-Vapour, of the System Argon-Nitrogen.* **G. Holst** and **L. Hamburger.** (K. Akad. Amsterdam, Proc. 18. Nos. 4–5. pp. 872–894, 1916.)—The percentage of nitrogen in the nitrogen-argon mixtures investigated was determined by means of (1) glow discharges in potassium vapour and (2) a baroscope. A systematic difference between the results obtained by these two methods indicates that the value hitherto assumed for the atomic weight of argon might not be quite accurate. Since this difference disappears on adoption of Schultze's value for the specific gravity of argon [see Abs. 1771 (1915)], the accuracy of this value is rendered highly probable; a preliminary direct determination gave a value in good agreement with Schultze's result. New measurements of the vapour pressures of oxygen, argon, and nitrogen have been made, and the results are discussed in relation to those of other observers. Accurate determination of the triple-point of argon gives $T = 83{\cdot}81°$ and $p = 521{\cdot}4$ mm. The initial and final points of condensation of argon-nitrogen mixtures have been determined with an accuracy corresponding with about 0·02 deg., and the saturated vapour-volumes are given. The observations with the mixtures are compared with the equation of state in the form, $pv/760 = RT(1 + B/v)$, the accuracy in $pv/760$ being about 0·1 %. Within the range of temperatures investigated, the values of $\log p$ for the mixtures may be represented as a linear function of $1/T$ for both the initial and final points of the condensation. The pv- and Tx-diagrams have also been constructed. The compositions of the gas-phase (r) and of the liquid phase (r') satisfy the relation $\log r' = a + b \log r$. From the shapes of the curves in these diagrams conclusions are drawn concerning a possible fractional distillation of the argon-nitrogen mixtures. T. H. P.

218. *Fourier Coefficients of Natural Radiation.* **M. v. Laue.** (Ann. d. Physik, 48. 5. pp. 668–680, Nov. 30, 1915.)—In reply to A. Einstein, this paper discusses mathematically the statistics of the Fourier coefficients of natural radiation. [See Abs. 95 and 96 (1916).] E. H. B.

219. *Radiation Theory.* **R. Emden.** (Phys. Zeits. 16. pp. 282–285 Aug. 1, 1915.)—A theoretical treatment comprising a new derivation of Stefan's law and a discussion of Wien's displacement law and the temperature of radiation. E. H. B.

220. *Thermodynamical Laws of Periodic Movements which follow from the Principle of Least Action.* **K. Försterling.** (Ann. d. Physik, 47. 8. pp. 1127–1138, Sept. 14, 1915.)—Analytical treatment unsuitable for detailed abstraction. E. H. B.

221. *An Elementary Account of the Quantum Theory.* **J. Rice.** (Faraday Soc., Trans. 11. pp. 1–18, Oct., 1915.)

222. *An Interpretation of van der Waals' Equation from the Standpoint of Volume determined by Equilibrium of Pressures.* **W. V. Metcalf.** (J. Phys. Chem. 19. pp. 705–719, Dec., 1915.)

223. *A Modified Conception of the Equipartition Law of Kinetic Energy.* **E. A. Holm.** (Ann. d. Physik, 48. 4. pp. 481–518, Nov. 9, 1915.)—Highly mathematical treatment.

224. *Thermodynamics of Condensed Systems.* **A. Smekal.** (Ann. d. Physik, 47. 8. pp. 1139–1144, Sept. 14, 1915. From K. Akad. Wiss. Wien, Ber.)—Mathematical.

SOUND.

225. *Sound Recorder with Small Soap Film.* **S. Garten.** (Ann. d. Physik, 48. 3. pp. 273–306, Oct. 29, 1915.)—A very small chamber is provided with a cross-shaped opening (3 mm. by 2·5 mm.) in its upper face, its lower face being of glass. By a glass funnel and rubber tube the sound to be examined and recorded is conveyed to this chamber. The cross-shaped opening is covered with a soap film and at its centre is placed an iron particle which is held in place by the action of an electromagnet. A microscope is mounted with its axis horizontal and the chamber and soap film are placed at an angle of 45° and at the focus of the objective. Thus when the membrane is set in vibration by the sound under test the motion of the iron particle can be observed. Records of the various sounds can also be made on a moving sensitive film. Twenty-six photographic reproductions are given, comprising the sounds from forks, organ-pipes, the noise from an electric spark, also vowel sounds sung at various pitches. E. H. B.

226. *Estimating Distances at Sea in Fog or Thick Weather.* **J. Joly.** (Roy. Soc., Proc. 92. pp. 170–175, and 176–183, Jan. 1, 1916.)—The author's method is similar to that proposed by C. E. Kelway [Brit. Pat. 12,124 of 1899], although the latter's work is not referred to, and is based on the differing velocities of signals in different media. Besides the use of simultaneously emitted "wireless" signals and aerial sound signals as in Kelway's arrangement, the author proposes the simultaneous striking of a submarine bell and a bell above the surface of the sea. The scheme is then elaborated and its application to the avoidance of collision at sea discussed. In a later paper (Ibid. pp. 252–260, Feb. 1, 1915) the author describes a calculator by means of which the necessary computations can be rapidly carried out. L. H. W.

227. *Acoustics of Armoury at Illinois.* **F. R. Watson.** (Brickbuilder, pp. 1–4, Oct., 1915. Reprint.)—The armoury at the University of Illinois presents an unusual case of defective acoustics because of its very large volume and comparatively small absorbing power. It was built to fulfil the usual requirements of an armoury in regard to military drills; but in addition, it has been used on several occasions for convocations and assemblies where the audiences have been very large. The acoustics proved to be impossible for speaking and music. In view of the proposed continued use of the building for such assemblies, the author carried out an investigation to determine the possibilities of making it satisfactory in its acoustical properties.

The armoury is 400 ft. long, 212 ft. wide, and 98 ft. high at the centre of roof, which is almost semicircular (and at once reminds an English reader of St. Pancras Station, London). Three experiments were tried to distribute the sound as desired. These utilised parabolic reflectors, a special megaphone, and loud-speaking telephones respectively. None of these proved successful because of the long-continued reverberation from the roof and walls.

Accordingly it appeared impossible to use the building for speaking unless its excessive reverberation could be reduced. Sabine's method was used for this purpose. His formula for the time t of reverberation is $t = kv \div a$, where k is a constant, v the volume of the room, and a the sound-absorbing power of all its exposed surfaces. Applying this to the building in question $v = 6,652,000$ cub. ft., and the total absorbing power, without an audience, is 13,400 units. The time of reverberation was calculated to be 24 secs. This is unusually large. The auditorium of the University of Illinois, seating 2200, had a reverberation of 9 secs. before its acoustical correction and was considered to be very bad. Further calculations showed that the introduction of 50,000 sq. ft. of hair felt would reduce the value of t only to 4·66 secs., which is still too large for easy speaking; so canvas curtains were introduced to enclose a space 212 ft. by 134 ft. and 35 ft. high. The time of reverberation for this enclosure with an audience of 4500 was then estimated to be 1·1 secs. This arrangement was carried out and auditors in all parts of this space could then hear and understand the various speakers. E. H. B.

228. *Sound Speeds and Ratios of Specific Heats of Gases by Kundt's Dust-figures.* **G. Schweikert.** (Ann. d. Physik, 48. 5. pp. 593–667, Nov. 30, 1915. Abbreviated Dissertation, Bonn.)—A very elaborate descriptive, mathematical and experimental treatment of the subject with many tables, a three-page bibliography, and two whole-page plates of photographic reproductions of the dust-figures. Part of one of the concluding tables is as follows:—

Gas.	Molecular Weight.	Specific Heats at 20° C.			
		Ordinary.		Molecular.	
		C_p.	C_v.	C_p.	C_v.
Air	28·96	0·2389	0·1700	6·918	4·924
CO	28·00	0·2464	0·1753	6·900	4·905
N_2	28·02	0·2464	0·1753	6·905	4·911
O_2	32·00	0·2164	0·1540	6·924	4·929
HCl	36·47	0·1932	0·1376	7·046	5·017
CO_2	44·00	0·2023	0·1564	8·904	6·882
N_2O	44·02	0·2093	0·1633	9·214	7·187
SO_2	64·07	0·1570	0·1240	10·059	7·943
NH_3	17·034	0·5245	0·4032	8·933	6·869
C_2H_4	28·032	0·3486	0·2771	9·773	7·769
C_2H_2	26·016	0·3760	0·2993	9·783	7·786

E. H. B.

229. *Vibrations in Flutes and Organ-pipes.* **W. Steinhausen.** (Ann. d. Physik, 48. 5. pp. 693–717, Nov. 30, 1915.)—An experimental research in which the condition of the air inside a flute when played upon is ascertained by a "search tube" that can be slid along so that its side opening or "search hole" is brought to any desired position. The paper is illustrated by photographic plates and diagrams. E. H. B.

230. *Bullet Sound-Waves and Crack of a Whip.* **H. P. Maxim.** (Scientific American, 113, p. 231, Sept. 11, 1915.)—After noticing the specially sharp crack from certain bullets and missing it from others and photographing these bullets in flight, the author finds that those give the sharp crack like a whip that have a speed greater than the ordinary speed of sound in air, and thus show on the photographs the breast wave. E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

231. *Charge of the Electron and Avogadro's Number.* **A. Schidlof.** (Archives des Sciences, 40. pp. 339–340, Oct., 1915. Paper read before the Soc. suisse de Physique.)—From the results of experiments made with drops of pure mercury, Schidlof and Karpowicz found the charge of the electron to be $4{\cdot}82 \times 10^{-10}$ e.s. unit, and by a similar method Targonski found the value $4{\cdot}68 \times 10^{-10}$. These results, which agree with others previously found, indicate that Avogadro's number lies between $6{\cdot}0$ and $6{\cdot}2 \times 10^{23}$. Study of the Brownian movement of spherules suspended in a gas or liquid leads to a much greater value. The suggestion is made, therefore, that the theoretical laws of Brownian movement are not strictly accurate and only approach the truth if the free path among the gas molecules is large in comparison with the radius of the spherules. It is possible also that the observations are perturbed by accidental sources of error which superimpose their effect on the Brownian movement. T. H. P.

232. *Electrostatic Field of Force.* **J. Spielrein.** (Archiv f. Elektrotechnik, 4. pp. 78–85, 1915.)—A mathematical discussion of the geometrical properties of the electrostatic field of force. The investigation is carried out with the object of facilitating the predetermination of the electric stresses in insulating materials. A. J. M.

DISCHARGE AND OSCILLATIONS.

233. *Most Effective Primary Capacity for Tesla Coils.* **W. M. Jones.** (Phil. Mag. 31. pp. 62–74, Jan., 1916.)—It is generally assumed, from Drude's work, that a Tesla coil gives the best effect (*i.e.* the highest secondary potential for a given primary discharge potential) under the condition $L_1C_1 = L_2C_2$. Taylor Jones has recently shown [Abs. 1460 (1915)] that the above condition does not apply if the adjustment is made by varying the primary capacity alone, but that in this case the "optimum" value of C_1 is considerably greater than the resonance value. The author's experiments were undertaken to test these conclusions experimentally, and also to determine experimentally the optimum primary capacity and relative values of the max. secondary potential for various values of the coupling. The variation of secondary potential was obtained by noting the distance at which a neon tube would glow. It is clear from the experimental results that if the adjustment of the Tesla coil is made by varying the primary capacity alone, then the optimum value of C_1 exceeds the resonance value. Curves are given in which the experimental values are compared with those deduced from theory. I. W.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

234. *Light-sensibility of Copper Oxide.* **A. A. Pfund.** (Science, 42. pp. 805–806, Dec. 3, 1915.)—The fact that selenium changes its electrical conductivity under the influence of light was discovered by May in 1873. Since that time it has been found that sulphur, shellac, paraffin, anthracene, and several other

substances possess this property of light-sensibility to a slight extent. The most noteworthy addition to the list was made by Jaeger, who discovered the light-sensibility of stibnite (native Sb_2S_3) in 1907. Since a careful study of the behaviour of these substances is bound, ultimately, to shed light on the mechanism of metallic conduction, it seemed worth while to continue the search for other substances which show marked light-sensitiveness. Recently the author found that copper oxide (Cu_2O presumably) shows the effect quite unmistakably. The fundamental facts which have been established for this new light-sensitive substance are: (1) The conduction is electronic and not electrolytic; (2) the increase in conductivity, occasioned by light, is distinctly different from that produced by a heating effect; (3) the conductivity increases with the applied voltage, *i.e.* Ohm's law is not obeyed (voltage effect); (4) the region of increased conductivity spreads slightly to portions of the material not illuminated (transmitted effect); (5) the region of highest sensibility lies in the ultra-violet near $\lambda = 2800$ Å.U.; (6) cooling in liquid air increases the percentage change in conductivity and displaces the sensibility maximum in the red toward shorter wave-lengths; (7) the relation between the radiant energy absorbed (E) and the resultant change in conductivity (C) is very approximately of the form $C = KE_\beta$, where K is a constant and β lies near 0·5. While the percentage change in conductivity upon illumination is much less than that of Se and stibnite, the comparatively high conductivity of copper oxide makes the absolute increase quite large. The best cell thus far constructed has a resistance of 15,200 ohms at 17° C. for one volt. The change in conductivity occasioned by the light from a 40-watt tungsten lamp at 20 cm. is about 15 %. The area exposed to radiation is about 12 mm.^{2}. If this cell be connected to a 2-volt cell and a galvanometer (forming part of a simple potentiometer) a sensitive device for detecting radiant energy is produced. Exposing the cell to daylight in a moderately-lighted room throws the galvanometer spot of light violently off the scale. Monochromatic radiations which are quite too feeble to affect a sensitive radio-micrometer, bring about large deflections when allowed to fall on the copper-oxide cell. If the cell be connected to a telephone receiver and battery, and if an intermittent light-beam of definite frequency be allowed to fall on the cell, a clear, musical note is heard. Further experiments are in progress. A. E. G.

235. *Condenser Losses with Solid and Liquid Dielectrics.* **F. Tank.** (Ann d. Physik, 48. 3. pp. 307–359, Oct. 29, 1915.)—Describes an investigation of the connection between the losses in condensers with solid and fluid dielectrics and the anomalies observed in the charging and conduction currents of these condensers. It is found that the alternating-current losses in solid dielectrics arise almost entirely from dielectric after-effect and can be expressed by means of two constants depending on the nature of the material, and determinable in any given case by static experiments. The Joule losses account for less than 1 % of the whole, while losses from other sources do not appear to be present in the a.c. field. The losses in liquid dielectrics are found to be due to ionic conduction, and to disappear if the dielectric is sufficiently purified. J. W. T. W.

236. *Electrical Conductivity of Thin Air Films.* **E. Branly.** (Comptes Rendus, 161. pp. 759–765, Dec. 20, 1915.)—This paper describes very fully an extension of the author's work on dielectric films [Abs. 497 (1913)]. He shows that air films, 4 μ to 5 μ thick, under a pressure of 1 volt or less, have a definite conductivity which is influenced by a spark or by shock. I. W.

237. *Measurement of Inductance of Low-resistance Standards.* **F. Wenner, E. Weibel, and F. B. Silsbee.** (Bureau of Standards, Bull. 12. 1. pp. 11–21, 1915.)—Values hitherto obtained for the residual inductance of "non-inductive" standards of low resistance have been based upon the calculated inductance of some conductor. The inductances of standards of odd shapes have been obtained by measuring the differences between their phase angle and that of the calculated standard. The methods described by the authors determine the phase angles of low-resistance standards without recourse to computed values. In the first method the sum of the phase angles of two resistance standards is given. By using 8 resistance standards 8 sums can be measured from which each phase angle can be obtained. The second method makes use of a standard whose resistance can be changed (*e.g.* by varying the temperature of a copper standard) without changing its inductance. The measurement consists in determining the change in phase angle or in time-constant when the resistance is changed by a known amount. The second method was found to be much simpler than the first. F. E. S.

238. *Theory of Piezoelectric Phenomena.* **W. Voigt.** (Ann. d. Physik, 48. 4. pp. 433–448, Nov. 9, 1915.)—The author points out that the theory of piezo-electricity he has previously developed is only approximate. The phenomena are complicated by secondary effects. When a crystal subjected to mechanical stress becomes electrified, the electric intensity may cause secondary strains, and these would contribute a further amount to the electrical effect observed. Similarly in the reverse case, when the crystal is brought into an electric field, the deformation observed will be due to primary and secondary causes. In the present paper the author investigates theoretically the case of a cylinder of Iceland spar subjected to bending or torsion, such as he has employed in recent experiments [Abs. 1749 (1915)]. In this special case the secondary effects are of small magnitude, and lie well within the errors of experimental observation. In the case of the earlier class of experiments where the electric effect was measured by connecting two faces of the crystal directly to an electrometer, the analysis would be exceedingly complicated. The author considers, however, that the magnitude of the secondary effect in such cases would be much greater than in those where a compensation method was used. L. L.

ALTERNATING CURRENTS AND MAGNETISM.

239. *Ideal or Hysteresis-free Magnetisation.* II. **W. Steinhaus and E. Gumlich.** (Deutsch. Phys. Gesell., Verh. 17. 21. pp. 869–884, Nov. 15, 1915. From the Physikal.-Techn. Reichsanstalt.)—This paper is the second of a series on experimental investigations of the theory of ferromagnetism [see Abs. 1759 (1915)]. An ideal, *i.e.* hysteresis-free, magnetisation curve was obtained for ellipsoidal specimens by means of a modified magnetometric method. The specimens were 33 cm. long and 0·6 cm. in diam., and included soft iron, soft steel, hardened steel, cast iron, a silicon alloy, and a Heusler alloy. The magnetising coil was surrounded by another coil which was employed in the usual way to remove the hysteresis from the specimen by means of a diminishing alternating current, while a given small field was applied by the magnetising coil. This process was repeated for stronger constant fields in the magnetising coil after the usual manner of magnetic cycles. It was found that the true field, H–NI, was practically zero for values of $4\pi I$ up to 5000, *i.e.* the initial susceptibility of the specimen under the above conditions was infinite. G. E. A.

240. *Variation with Temperature of the Coercive Force of Steel and Iron.* **R. Gans.** (Ann. d. Physik, 48. 4. pp. 514–520, Nov. 9, 1915.)—The author has measured the coercive force of steel and soft iron over the temperature-range —185° to 700° C. The experimental results for steel have already been given [Abs. 1832 (1915)]. In the case of soft iron the curve co-ordinating coercive force and temperature shows an abrupt change between 400° and 500° C. similar to that for steel. At low temperatures, however, like Ni [Abs. 161 (1914)], it approaches a constant value (2·444 c.g.s. units at —185° C.). The author assumes for soft iron two Curie temperatures of loss of ferromagnetism, viz. 929° abs. when the iron is below 400° C., and 1063° abs. when above 500° C. For each range, the experimental results can then be represented by the formula $C/C_0 = 3L(x)/x$, where $L(x) = \coth x - 1/x$ and $T/\Theta = L(x)$. In this C_0 is the coercivity at absolute zero (2·488), C the coercivity at absolute temperature T, and Θ the corresponding Curie temperature. According to the theory of Weiss the ratio of the moments of the elementary magnets in the two conditions will be $\surd(\Theta_1/\Theta_2)$ (=1·070). The measurements of Onnes and Weiss ascribe 11 magnetons to the molecular magnet at low temperatures. It would thus appear that for temperatures above 500° C., the molecular moment being 11 × 1·070 (=11·77), there are approximately 12 magnetons. The abrupt change in the curve between 400° and 500° C. is thus characterised by the transformation of the 11 magnetons in the molecular magnet to 12. L. L.

241. *Magnetic Transformation of Cementite.* **K. Honda and H. Takagi.** (Iron and Steel Inst., J. 92. pp. 181–189, 1915. Tôhoku Univ., Sci. Reports, 4. 3. pp. 161–167, and pp. 261–269, 1915. Engineering, 100. pp. 665–667, Dec. 31, 1915.)—Previous work on this point [see Abs. 515, 516 (1913)] is supplemented by the present paper. Specimens of white pig-iron of carbon content up to 4·15 % were studied by means of the magnetometric method, and also thermally. For the latter purpose, the Roberts-Austen differential method was used in which thermo-couples were connected to the specimens and to a copper neutral piece surrounding the specimen. The specimens had dimensions 25 × 5 × 5 mm. and were tested magnetically in a field of 158 c.g.s. The results are illustrated by means of intensity-temperature and cooling curves. The critical temperature of cementite is given as 220° C., a little below the value found by S. W. J. Smith. The cooling curves show evolution of heat between 160° and 210° C.; the amount of heat evolved increases with the carbon-content in general. These facts are in harmony with the view that the heat evolution is due to the magnetic transformation of cementite. Photomicrographs are appended. The paper concludes with a note on the A3 transformation in pure iron as studied in four specimens of pure material tested magnetically in a nitrogen atmosphere. The susceptibility-temperature curves obtained afford data unfavourable to the magneton theory. G. E. A.

242. *Some Problems of Electromagnetic Induction.* **G. W. O. Howe.** (Electrician, 76. pp. 169–172, Nov. 5, 1915.)—The question is often raised whether when a cylindrical bar magnet is rotated about its axis the magnetic field rotates with it. This problem is examined with reference to an arrangement in which a shaft supports a circular metal disc rigidly fixed to it and is mounted coaxially with a magnetising coil. If the coil is stationary and the shaft with the disc be rotated, the arrangement is similar to the Lorenz apparatus, and an e.m.f. will be induced radially to the disc. It is not correct to reason that if the shaft be kept at rest and the coil rotated about its axis the relative motion is the same and therefore the same e.m.f. will be induced. When the disc is rotated current may be taken off it by means of brushes touching its centre and periphery. The torque exerted is not produced between the disc and the magnetising coil, but acts between the disc and the external circuit connected to the brushes. Turning to the case of unipolar induction in a circuit connected to the end and centre of a straight bar magnet rotating about its axis, the e.m.f induced is localised in the material of the bar magnet and not, as often supposed, in the stationary circuit. If the magnet be rotated without connecting up the external circuit electric charges will be collected at the middle and the two ends, and there will be an external electric field produced by these charges. A long metal cylinder rotated about its axis in a uniform field parallel to its axis will become electrically charged on its inner and outer surfaces. Poincaré [Abs. 1487 (1900)] has discussed the case of an ebonite ring rotated about its axis between two metal rings, a bar magnet being held along the axis of rotation with one of its poles at the centre of the ebonite ring. When the rotation takes place the metal rings on either side of the ebonite become charged with equal and opposite electric charges. The writer argues that Poincaré was wrong in supposing that the potential undergoes a sudden jump in value at the surface of the ebonite, and states that the potential gradient is a gradual one through the thickness of the ebonite. With regard to the question whether the induction of e.m.f. should be considered as due to the cutting of lines of force or to the change of flux through a circuit, it is pointed out that when the field is stationary and the conductor is moved, the two conceptions agree, but that when the magnetic field is changing we must adopt the second point of view. **E. A. Biedermann.** (Ibid. pp. 208–209, Nov. 12, 1915.) **W. T. Maccall.** (Ibid. pp. 209–210, Nov. 12, 1915.) **G. W. O. Howe.** (Ibid. p. 210, Nov. 12, 1915.) A. J. M.

243. *Magneto-chemistry of Copper Salts and the Magneton Theory.* **B. Cabrera** and **E. Moles.** (Archives des Sciences, 40. pp. 284–290, Oct., 1915.)—The results of Koenigsberger [Abs. 824 (1899)] confirm Wiedemann's law for solutions of copper sulphate, whereas those obtained by Liebknecht and Wills with solutions of cupric chloride, bromide, sulphate, and nitrate [Abs. 528 (1900)] lead to fractional numbers of magnetons. In the case of copper sulphate, Meslin's measurements indicate a diminution of the susceptibility on dilution [Abs. 784 (1906)]), and Chéneveau also found a slight variation [Abs. 615 (1910)]. The results of the authors' measurements of the susceptibilities of solutions of cupric sulphate, chloride, and nitrate reveal a distinct variation with the concentration of the solutions, but this is in the opposite sense to that observed by Meslin and by Chéneveau. As regards the number of magnetons, n, no tendency towards an integral value is observable, and it is assumed that the susceptibility of the dissolved salt is influenced by the extent of its dissociation, α. Curie's constant should, therefore, be a function of α and should approach its true value for the kathion, Cu^{++}, as α approaches unity. The values of α determined (1) by Pickering from cryoscopic measurements, and (2) by Arrhenius from conductivity measurements give for n the values (1) 9·90 and (2) 9·98, which indicate that the kathion, Cu^{++}, contains 10 magnetons. The sense in which these values differ from 10 is explainable on the assumption, which is almost certainly correct, that dissociation of copper sulphate yields complexes of the type $Cu_2SO_4^{++}$, as well as the simple ions, This reasoning is not applicable to the cases of cupric chloride and nitrate, since with these

there are very large proportions of the ions, $ClCu^{++}$ and $(NO_3)_2Cu^{+}$, apart from complexes of the type just mentioned. Measurements are now being made for dilutions greater than those permitted by Quincke's method.

T. H. P.

244. *Effect of Electric Oscillations on Magnetic Properties of Iron investigated by the Campograph.* **J. A. Fleming** and **P. R. Coursey.** (Phys. Soc., Proc. 28. pp. 35–49; Disc., 49. Dec., 1915.)—The author has previously described an instrument for photographing and delineating physical curves. This campograph, as the author terms it, has been improved, and results obtained by using it to investigate the effect of electric oscillations on the magnetic behaviour of iron are here given. For a complete comprehension of the paper the numerous curves reproduced in it have to be referred to; it is only possible here to reproduce the author's convenient summary, as follows:—

(1) When an iron wire is taken slowly through a magnetic cycle and a superposed high-frequency magnetising force is also applied, then, if the max. value of the slowly periodic longitudinal magnetic force does not exceed a certain value, the effect of the oscillations is to increase the area of the hysteresis loop and also the magnetisation at the ends of the cycle. (2) If the slowly periodic force has a large max. value then the hysteresis loop is diminished in area, but the max. magnetisation remains unaltered. (3) The increase in area of the hysteresis loop is generally less for high-frequency than for low-frequency oscillations. (4) If oscillatory currents are passed along the iron wire whilst at the same time the iron is taken slowly through a longitudinal magnetic cycle with continuous current, then when the oscillatory current has a small r.m.s. value the effects are generally similar to those produced by longitudinal oscillatory magnetic forces. If the oscillatory current is relatively large, then their effect is to reduce the hysteresis and magnetisation at the ends of the cycle. This last action is due to the circular magnetisation produced by the longitudinal current, which grips the magnetic molecules of the iron, and prevents their longitudinal colineation and reduces also the hysteresis. (5) The effect of superimposing on a steady feeble longitudinal magnetic force an alternating magnetic force either by undamped or damped oscillations is greatly to increase the permeability at the ends of the cycle, provided the oscillatory force does not exceed a certain value. Beyond that a diminution sets in.

L. H. W.

245. *New Method of Measurement for Study of Paramagnetic Substances in very Dilute Solution.* **A. Piccard** and **E. Cherbuliez.** (Archives des Sciences, 40. pp. 342–344. Oct., 1915. Paper read before the Soc. suisse de Physique.)—The following method admits of the investigation of solutions 10–100 times more dilute than those capable of measurement by the old method. A circular tube contains in its lower half the solution to be examined, and in its upper half the pure solvent. The part of the tube containing one of the two horizontal surfaces of separation is placed between the poles of an electromagnet, while the part containing the other surface of separation is attached to a cathetometer so as to be movable vertically. The circulation of the liquid is rendered visible by means of a microscope directed towards small solid bodies floating in the liquid at a position where the tube is capillary. The position of the movable tube is adjusted until the liquid is motionless. This operation, which occupies less than a minute, is repeated several times with the magnet excited and not excited. The difference between the two heights represents the magnetic ascension of the solution with relation to the solvent. If the intensity of the field, the densities of the two liquids, the coefficient of magnetisation of the solvent, and the concentration of the solution are known, the coefficient of magnetisation of the dissolved substance is readily calculable. The method is found to give good results. T. H. P.

246. *Sun-spots and Terrestrial Magnetic Disturbances.* **A. L. Cortie.** (Roy. Astron. Soc., M.N. 76. pp. 15–18, Nov., 1915.)—A compilation has been made of the magnetic disturbances recorded at Stonyhurst for the period 1889–1913, including three solar minima, 1889·6, 1901·7, and 1913·4, and two solar maxima, 1894·1 and 1906·4. The total number of disturbances was 2028, 275 being given as *great*, and 29 as *very great*. In discussing these in relation to sun-spot activity, use is made of well-known graphical presentations of spot areas or numbers. Tables are given showing that magnetic disturbances are relatively more numerous when the sun-spot area is decreasing than when it is increasing. Numbers are then determined representing the relation between mean yearly number of magnetic disturbances and mean daily disc-area of spots, and it is shown that these appear to depend on the position of the spots, those nearer the equator being most effective. An example of the combined effect of great disturbance and favourable position with respect to the earth occurred in the case of the sun-spot which appeared from 1915, June 12 to 21. This was also notable in being very near the solar equator, and the spectroheliographic records show evidence of great perturbations. The greatest magnetic storm of the present cycle occurred on June 17, accompanied by brilliant auroræ. C. P. B.

247. *Galvano- and Thermomagnetic Effects.* **T. Huerlinger.** (Ann. d. Physik, 48. 1. pp. 84–97, Sept. 28, 1915.)—The author deals mainly with the recent work of Zahn [Abs. 1386 (1915)], and as a result of his own theoretical investigation he considers that for the cause of the difference between the d.c. and a.c. values of the Hall coefficient a different explanation from that given by Zahn must be sought. L. H. W.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

248. *X-ray Apparatus to give the Best Form of Discharge.* **B. Winawer.** (Phys. Zeits. 16. pp. 391–395, Nov. 1, 1915.)—With the recent rapid developments in the production and application of high-tension currents, it is becoming of increasing importance to realise what are the chief requirements of an X-ray tube to which such currents are supplied. It is important to know how such characteristics as "range of penetrating power," "quality" and "quantity" of the X-radiation can be varied, and what sources of the current supply of the X-ray tube are most desirable. From a consideration of the work of Carter, Seitz, Whiddington, and others [see Abs. 291 (1907)], the author builds up a theory which he verifies by experimental observation. Two conditions which the source of current must satisfy are stated: (*a*) The most suitable source of current is that which gives a definite permissible load with the smallest possible number of short-duration current impulses. (*b*) Of two different sources of current, the more suitable for use with an X-ray tube is that which for a given load, produces the greater heating of the anti-kathode. A. B. W.

249. *New Method of Surgical Radioscopy using Red Light.* **J. Bergonié.** Comptes Rendus, 161. pp. 683–685, Nov. 29, 1915.)—It is first shown that the two methods which have been most extensively used up to the present are defective, and it is claimed that the new method removes these objections. Operations are carried out in a black chamber, the field of operation being lighted by an intense and saturated red light, which comes from a spectroscopically analysed source, and gives neither green nor yellow rays such as are emitted by a fluorescent screen when Röntgen rays impinge on it. The method of using the radioscope in conjunction with this red light is described, as well as the way in which a satisfactory red light has been produced. In practice it has been proved that the duration of each exposure to Röntgen rays scarcely exceeds 30 secs., and that the number of such exposures depends upon the case in point. It is noted, among other things, that in monochromatic red light arterial blood is hardly tinted, while venous blood is markedly different, and the slightest commencement of asphyxia makes itself known by an almost black colouration. A. E. G.

250. *Rôle of the X-ray Tube in X-ray Technique.* **P. Ludewig.** (Phys. Zeits. 16. pp. 438–450, Dec. 1, 1915.)—Employing the experimental observations of H. Kröncke (Dissertation, Göttingen, 1913) on the statical characteristics of X-ray tubes of different grades of hardness, the author sets forth a theory which involves the acceptance of the following conditions: (1) That hysteresis exists in a Röntgen-tube as in an electric arc; (2) that the hardness of the X-radiation is proportional at any instant to the p.d. across the tube; (3) that the high-tension voltage curve consists of a series of single short impulses.

Applying the theory suggested, several difficulties encountered in actual X-ray practice are removed, and a new solution is given to the problem of the production of very hard X-rays. A. B. W.

251. *Radiological Sextant.* **Loro.** (Archives d'El. Médicale, 23. pp. 337–340, Nov., 1915.)—This apparatus, which is easy to construct, takes up little room, and can be readily packed for transport, enables the surgeon to avoid all calculations and geometrical constructions. A diagram shows the essential parts, and a detailed description of the method of employing it in the operating theatre is given. [See also Abs. 1770 (1915).] A. E. G.

252. *New Radioscopic Method of Searching for Foreign Bodies.* **R. Ledoux-Lebard** and **Dauvillier.** (Comptes Rendus, 161. pp. 575–577, Nov. 8, 1915.)—The principle of the method is as follows: A ball C situated in the body will give on the fluorescent screen two images c' and c''. Now if a probe is introduced into the tissues its extremity will furnish two images which can only coincide with c' and c'' if the point of the probe coincides with C. It is evident that if the point is between C and the screen, the distance between its two images will be less than $c'\,c''$, and if the point lies between the bulb and C the distance between its images will be greater than $c'\,c''$. In order to obtain a satisfactory image a diaphragm is employed. A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

253. *Periodic System of the Elements.* **K. Fajans.** (Phys. Zeits. 16. pp. 456–486, Dec. 15, 1915.)—A comprehensive survey of recent work in this connection—in particular, the classification of the radio-active elements. The paper is divided into the following sections and subsections:—I. Important information on the relation between the chemical elements. II. Atomic weights of the radio-elements. III. Chemical properties of the radio-elements, (A) In general, (B) Polonium [RaF], (C) Actinium [Ac], (D) Chemically inseparable elements: Rad.Th–Th, Io–Th, UrX_1–Th, ThX–Ra, AcX–Ra, $MsTh_1$–Ra, RaD–Pb, Ur_2–Ur_1. IV. Place of the radio-elements on the periodic system. V. "Displacement" theories (theories of v. Lerch, Lucas, v. Hevesy, Soddy, Russell, etc., on the shift of position of a product in the periodic table, on emission of an α- or β-particle). VI. Atomic weight and "Life" of isotopes. VII. End products of the disintegration-series and the isotopes of lead (Ur-lead, thorium-lead, ordinary lead, also ionium and thorium). VIII. Structure of the atom. IX. Properties of isotopic elements; (1) theoretical discussion, (2) radio-active properties, (3) X-ray and γ-ray spectra, (4) ultra-violet and visible spectrum, (5) atomic-volume and density, (6) solubility of salts, (7) electro-chemical potential, (8) diffusion, (9) viscosity, (10) magnetic properties. X. The present system of elements; (1) atomic number and nuclear charge of the elements, (2) anomalies of the periodic system, (3) rare earths, (4) eighth group, (5) number of elements, (6) helium and hydrogen as the fundamental units of the elements and the transmutation of the latter, (7) arrangement of systems of elements.

The original paper should be consulted as a short abstract is impossible.

A. B. W.

254. *Molecular Attraction.* XII. **J. E. Mills.** (J. Phys. Chem. 19. pp. 650–659, Nov., 1915.)—When P represents the total pressure, that is, the numerical sum of the external and internal pressures, it is found that the relation, $dP/P = dT/T$ [see Abs. 770 (1915)], holds very approximately over such a wide range of conditions as to suggest that it may always be true for constant-volume and for phase-change equilibrium conditions. The relationships between several of the deductions made in the previous paper are discussed and the following further relation derived: The amount of energy retained by a system of n-particles forming a stable system under the action of the molecular attractive force is equal to the amount of energy given out by these particles in coming into the system from an infinite distance apart. The effect of temperature on this relation is not yet understood. T. H. P.

255. *Electrical Synthesis of Colloids.* **H. T. Beans** and **H. E. Eastlack.** (Am. Chem. Soc., J. 37. pp. 2667–2683, Dec., 1915.)—The specific conductivity due to the colloid proper of metallic hydrosols of average concentration is of the order of 10^{-10} mhos or about 0·0001 of that of conductivity water. There is, however, a further conductivity due to the formation of electrolyte, by "oxidation" of the metal, whereby the metal enters the liquid as ion, instead of as colloidal metal. This "oxidation" is much more marked in the electrical dispersion of Pt in water than in the case of Au; and electrically prepared colloidal Pt (in water of conductivity $1\cdot2 \times 10^{-6}$ mhos) is much more stable than similar gold sols; the conductivity of the free electrolyte in the Pt sols is about 0·0001 to 0·0008 N.

The stability of the gold sols can be increased by preparing them in presence of chloride, bromide, iodide, or hydroxide of concentration from 0·00005 to 0·005 N, but fluoride, nitrate, sulphate, and chloride do not produce this effect. It is, moreover, of no value to prepare the colloid in pure water and to add the electrolyte afterwards. The stabilising effect seems to be closely related to the ability of the ion to form stable compounds with gold. No Au, however, could be detected in the filtrate obtained after coagulation of the sol. The amount of Au compound necessary to stabilise the colloid is probably extremely minute.

Electrical synthesis of colloids is considered to consist of a thermo-mechanical dispersion of the metal which is followed by the formation of a colloidal complex between the dispersed metal and certain ions present in the medium. **T. M. L.**

256. *Properties of some Ni-Al and Cu-Ni-Al Alloys.* **A. A. Read** and **R. H. Greaves.** (Inst. of Metals, J. 13. pp. 100–150; Disc., 151–159, 1915. Mech. Eng. 35. pp. 380–383, May 14, and pp. 412–418, May 21, 1915. Abstract.)

257. *Hardening and Tempering High-speed Tool-steel.* **C. A. Edwards** and **H. Kikkawa.** (Iron and Steel Inst., J. 92. pp. 6–30; Disc., 31–46, 1915. Engineering, 100. pp. 349–352, Oct. 1, 1915.)

258. *Occurrence and Influence of Nitrogen on Iron and Steel.* **N. Tschischewski.** (Iron and Steel Inst., J. 92. pp. 47–97; Disc., 98–105, 1915.)—The subjects of this paper have already been dealt with in Abs. 605, 606 (1915). **F. C. A. H. L.**

259. *Phosphorus in Iron and Steel.* **W. H. Hatfield.** (Iron and Steel Inst., J. 92. pp. 122–134; Disc., 135–140, 1915. Engineering, 101. pp. 19–21, Jan. 7, 1916.)—The experiments were made on a series of specially prepared high-carbon alloys (white irons) with phosphorus contents ranging from 0·046 to 0·835%. The author's main conclusions are as follows:—(1) Phosphorus may be present up to 0·20 % in such alloys as those which form the subject of the experiments without unduly modifying the physical properties of the heat-treated material. (2) It would appear that about 0·25 % of phosphorus is necessary in the heat-treated condition before free phosphide is microscopically observable. A consideration of the experiments will make it clear that this percentage is the maximum that can be taken into solution in an iron-carbon alloy in the region of Ar1 to 900° C. when an excess of carbon is present. **L. H. W.**

260. *An Acid-resisting Alloy to replace Platinum in Construction of a Bomb Calorimeter.* **S. W. Parr.** (Am. Chem. Soc., J. 37. pp. 2515–2522, Nov., 1915.)—In the calorimetric combustion of coal from certain sources considerable quantities of nitric and sulphuric acids are produced, and if the metal of which the bomb is made is attacked by acid a twofold error arises in the results in that the heat credited to the fuel is increased by the heat of solution of the metal in the acid and, further, in that the determination of the acid is too low. The author has carried out a large number of experiments

with the object of finding a suitable substitute for Pt in the construction of a bomb calorimeter. Arranging the elements in electrochemical sequence and considering hydrogen as the dividing line between electro-positive and electro-negative metals, Cr, V, W, and Mo are found to be electro-negative whilst Co, Ni, and Fe are electro-positive. An attempt was made to alloy these two series of metals so that the ionisation tendency almost vanished. In this direction success was obtained with an alloy containing 80 % Ni and 20 % Cr, but the alloy was difficult to cast. These difficulties were surmounted by the addition of Cu and W, and finally the alloy having the composition Cu 6·42, Mn 0·98, Si 1·04, W 2·12, Ni 60·65, Al 1·09, Fe 0·76, Cr 21·07, and Mo 4·67 % was arrived at and given the name Illium. A temperature of about 1600° C. is required for casting, and in the cast condition it has a tensile strength of 50,000 to 55,000 lbs. per sq. in. After 24 hours' immersion in 25 % nitric acid no loss in weight was observed. The presence of Mo increases the resistivity to acids, but makes the alloy more brittle, and by omitting the Mo an alloy is obtained which can be drawn into wire, in which form it has a tensile strength of about 124,000 lbs. per sq. in. F. C. A. H. L.

261. *Liquid Junction Potentials.* **D. A. MacInnes.** (Am. Chem. Soc., J. 37. pp. 2301–2307, Oct., 1915.)—The probable value of the e.m.f., E_L, of the liquid junction connecting differently concentrated solutions of the same salt, may be expressed by the equations $E_L = E(2n_c - 1)/2$ and $E_L = E_t(1 - 1/2n_c)$, in which E is the voltage of a concentration cell without transference, and E_t that of the concentration cell with transference, each of the latter containing the solutions which are in contact at the liquid junction. These formulæ are in accord with the most accurate work on the potentials of concentration cells. By combining junctions to which the above equations apply with junctions the voltage of which may be computed by Lewis and Sargent's formula, the potential between any two uni-univalent salt solutions may be calculated to a few tenths of a millivolt. T. M. L.

262. *Influence of the Metallic Ion in Solutions upon the P.D.'s between the Solutions and a Metallic Electrode.* **F. K. Finney.** (Phys. Rev. 6. pp. 400–408, Nov., 1915.)—The metals can be arranged in a series in the order in which the presence of their ions in a water solution affects the solution tension of a metal when placed in the solution. This series is the same as the contact e.m.f. series; that is, if both electrodes be of the same metal, the electrode in the solution which contains the more electropositive ion has the higher solution tension and accordingly corresponds to the zinc electrode, while the electrode in the solution which contains the less electropositive ion corresponds to the copper of the ordinary Daniell cell. The order of this arrangement of the metals was determined as follows: K, Na, ammonium, Ba, Ca, Zn, Ni, hydrogen, Cu, and ferric iron. The results of the investigation indicate that, in accordance with Sanford's hypothesis, the solution of any of the electrolytes used decreases the specific inductive capacity of the water, but the more electropositive an ion the less is the decrease caused by it.

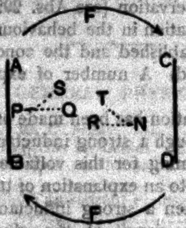
T. M. L.

263. *Potentials of Calomel and Hydrogen Electrodes.* **N. E. Loomis.** (J. Phys. Chem. 19. pp. 660–664, Nov., 1915.)—Recent results obtained by various investigators point to a lower value for the potential of the decinormal calomel electrode than that adopted by Loomis and Acree in their calculations [Abs. 414, 415 (1913)], the true value lying probably between

0·336 and 0·337 volt. On the basis of the former of these two figures, Loomis and Acree's values for the potential of the hydrogen electrode have now been recalculated. The experiments with both aniline hydrochloride and acetic acid show that the e.m.f. method gives results in closer concordance with those obtained by other methods when the value 0·336 volt is taken instead of a higher value for the potential of the decinormal calomel electrode.

T. H. P.

264. *Distribution of the Current in an Electrolyte situate in a Magnetic Field.* **A. Righi.** (Accad. Lincei, Atti, 24. pp. 1087–1098, June 24, 1915.)—Experimental and theoretical investigation of the effects produced by the magnetic field on the movement of the ions and electrons in a gas traversed by a current showed that the blows of these on the walls of the containing tube give a resultant tending to displace the tube itself [see Abs. 181 (1914)]. Analogy leads to the hypothesis that the ordinary ponderomotive force produced by the field on a wire traversed by a current is the resultant of the impacts of the electrons, to the motion of which is attributed mainly the propagation of electricity in metals. When applied to the case of liquids, this theory leads to a consequence capable of experimental verification. Two plane, vertical electrodes AB and CD, the former the positive, are assumed to be immersed in an electrolyte. In the absence of a magnetic field, a positive ion P acquires after an impact a velocity component along PQ, while a negative ion N acquires a component along NR. Under the influence of a magnetic field directed perpendicularly to the plane of the figure, for instance, in the sense indicated by the arrows F (direction of the circular current to which the field may be attributed), the positive ion P tends to move along the circular arc PS and the negative ion N along NT. Both ions are, therefore, displaced in the direction from BD to AC. The natural diffusion will tend to annul the variation in the ionic density which would tend to increase continuously, a permanent condition being reached with the density of the ions increasing from BD to AC. That this displacement of the current between the electrodes, foreseen by theory, actually occurs, is shown experimentally in various ways described in the original paper. T. H. P.



265. *Electrical Transference in Amalgams.* **G. N. Lewis, E. Q. Adams,** and **E. H. Lanman.** (Am. Chem. Soc., J. 37. pp. 2656–2662, Dec., 1915.)—An electric current passing through a dilute amalgam of sodium or potassium causes a transfer of the dissolved metal in the direction of the negative current. The number of equivalents carried per faraday is $2·9 \times 10^{-4}$ in Na amalgam of 8·24 atom %, and $0·29 \times 10^{-6}$ in Na amalgam of 0·577 atom %. In potassium amalgam of 2·16 atom % it is $8·6 \times 10^{-6}$. These effects are associated with the diminution of electrical conductivity which is produced by adding Na or K to Hg. This diminution is twice as great in dilute K amalgams as in dilute Na amalgam, whilst the transference-number is also twice as great for K as for Na. It is suggested that Li and Ca, which increase the conductivity of Hg, might perhaps show a transference in the opposite direction. **T. M. L.**

266. *Voltameter with an Aluminium Electrode.* **E. Freda.** (N. Cimento, 10. pp. 169–222, Sept.–Oct., 1915.)—A brief account is first given of previous work on the voltameter with an electrode of Al or of other metal showing analogous electrolytic behaviour. The hypotheses and theoretical considerations which have been advanced, mainly by G. Schulze, to explain the phenomena observed are discussed and various modifications suggested on the basis of the author's experimental results. A complete explanation of the behaviour of this voltameter necessitates the expansion of Schulze's theory by taking into account the phenomena of de-formation due to inverse currents. It is shown that the reduction of the layer of oxygen coating the formed Al electrode by means of inverse currents is not uniform, as Schulze assumed, but occurs only at certain points, this being in agreement with Corbino and Maresca's observation [see Abs. 292 (1907)]. The influence of the phenomena of de-formation in the behaviour of the voltameter towards alternating currents is established and the conditions necessary for a good valve-effect are determined. A number of experiments bearing on these points are described.

Mathematical determination has been made of the course which should be followed by discharge through a strong inductance of the voltameter with a formed Al electrode, assuming for this voltameter Schulze's second model. The formulæ derived lead to an explanation of the phenomenon observed by Corbino and Maresca, when a strong inductance and a galvanometer are included in the discharge circuit of the aluminium condenser. These theoretical deductions are, in general, in good accord with the results obtained by the experimental investigation of the discharge by means of a Braun tube and a rotating mirror. It is found that the characteristic course of the oscillatory discharge of an aluminium condenser is not influenced appreciably by electrolytic polarisation phenomena. When the Al is replaced by Zn, discharge of the voltameter through a strong inductance also indicates the existence of a limiting inverse voltage.

Comparison of the form which should theoretically be assumed by the discharge current, on the basis of Schulze's first model with the experimental results, shows that this model is incapable of explaining the course followed by the oscillatory discharge of the aluminium condenser.

The electrolytic conductivity observed by Corbino and Maresca for the stratum of oxide covering a formed Al electrode, is probably a property common to the thin, solid coatings deposited during formation on metals which exhibit, in suitable electrolytes, behaviour analogous to that of aluminium. **T. H. P.**